

NUTS AND VOLTS

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FEBRUARY 2007

EVERYTHING FOR ELECTRONICS

Interface Your iPod

An overview of the docking connector and ways to utilize it.

■ **Build the Digi-Log Clock**

■ **Build a Home-Made Weather Station**

■ **Access Flash Drives With a Microcontroller**

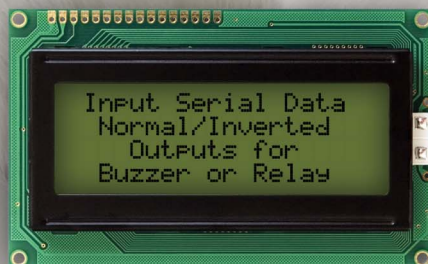
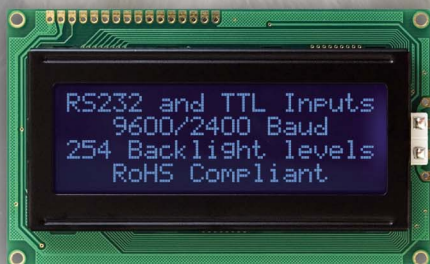
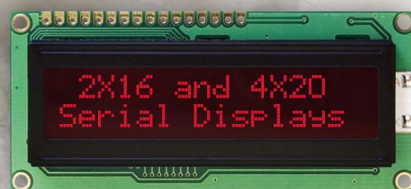
■ **Motor Test Lab**

■ **Hockey Scoreboard**



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Serial**LCD**



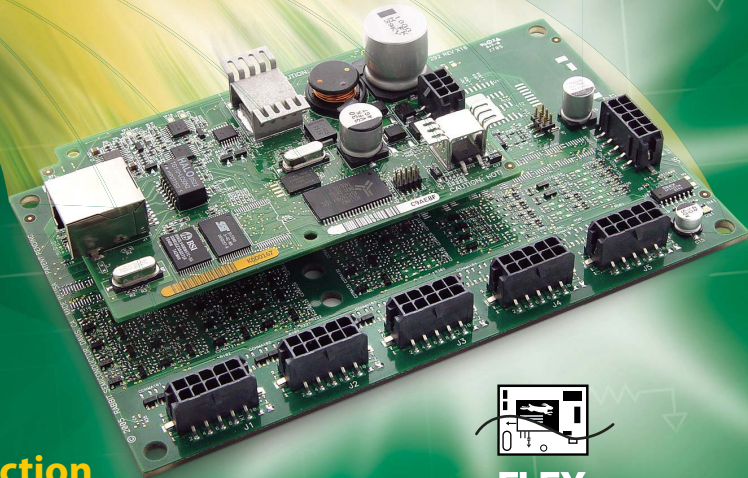
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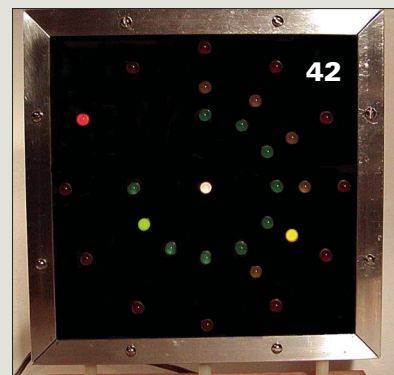
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PC-Based Test Equipment

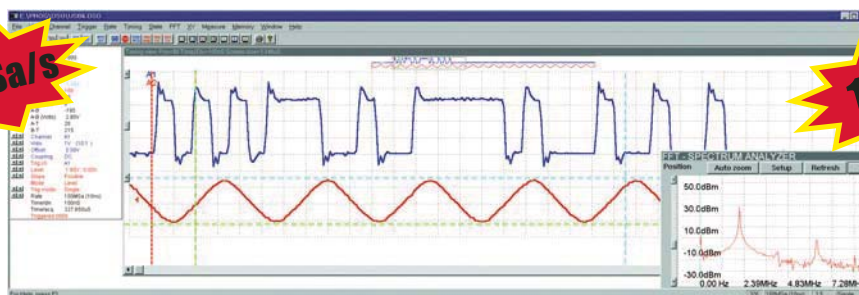
Digital Oscilloscopes

NEW!



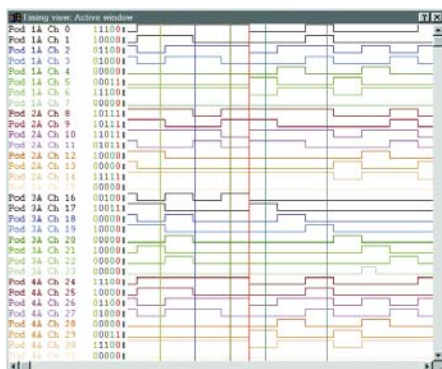
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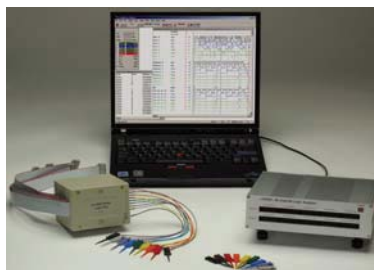


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READER FEEDBACK

NUTS AND VOLTS
EVERYTHING FOR ELECTRONICS

STAMP OF APPROVAL

NV is a great magazine and your January 2007 issue is especially good. I really enjoyed the 555 timer replacement, PICAXE, and Zigbee articles. I have long had a love/hate relationship with the 555 timer and was glad to see a PIC replacement that can do 555 functions with "one pin tied behind its back." I have been using the BASIC Stamp II for years at home and at work but the cost of the Stamp has limited my use somewhat at home, so I was also glad to see the PICAXE article. The PICAXE is especially attractive to me since I am familiar with Stamp Basic which is very similar to PICAXE Basic. One of the main things that has attracted me to the BASIC Stamp II is the fact that it has built-in touch tone frequencies. I work at a hospital and in a project that I have had operating continuously since 1997, a BS II is used to monitor various alarms (fire alarm, oxygen tank low, blood bank alarm, etc.) and then picks up a phone line and sends a code to the appropriate person on their pager. This system is used as a backup for the normal main alarm indications but, in many cases, gets the message to the appropriate person before the main alarms. So, my question is, do you know of a routine that has already been written for the PICAXE that will simulate touch tone frequencies? Thanks again for such a great magazine. I am anxiously awaiting parts 2 and 3 of the PICAXE series.

Ron Bean

GEIGER COUNTER QUERY

I enjoy reading NV and the Q&A column each month. The Geiger counter power supply question and answer (Jan 07, p. 23,24) was, however, a bit strange. There are a few points I wonder about. The reader asked for a 135 volt power supply circuit to replace the pair of 67-1/2V batteries used in the old device. An Internet search shows that a Geiger tube requires a precise voltage in the 500-1,000 volt range — typically 700 volts. No Geiger tube will "fire" at 135 volts. I wonder just what kind of device the reader actually has?

But the answer does not address the reader's stated question. The circuit (Figure 11) produces a range of five set voltages,

whereas the reader wanted a single value: 135 volts. Nonetheless, there is a safety issue with this circuit. A rotary switch is specified to select the bottom resistor that is part of the divider for the LR8 adjustable regulator. When, as shown in Figure 11, the switch is "between" contacts (is open), the bottom resistance is momentarily infinite. This causes the output (B+) voltage to shoot up to the input voltage — quite more than 200 volts. If a user was switching from, say, 22.5V to 45V, the output would hit 200-plus volts. Not safe. This deficiency can be remedied by using a make-before-break switch (not discussed), which makes the output safely drop below the currently set voltage and then rise to the next voltage. Alternately, you can directly connect the 30K resistor to ground and replace the 4.7K, 10K, 15K, and 20K resistors with 5.6K, 15K, 30K, and 60K values, respectively. This limits the output to 135 volts in all cases, including switch failure.

The circuit provides a 1.5 volt filament supply, which was also not requested by the reader. Even though a vacuum tube needs a heater supply, a Geiger tube does not. It doesn't have a cathode because the radiation to be detected ionizes the gas in the tube. This allows a pulse of current to flow. Without any amplification, there is enough current to drive a meter and headphones. Since Mr Byers knows his electronics, I believe my confusion is because the question was edited down, omitting details of the reader's Geiger counter. It is possible that he has a vacuum tube device? Then it would be at least 50 years old!

Winston Kim

Response: *The Geiger counter has an internal flyback transformer that steps up the 135 volts to 500 volts. BTW, 135 is rather unusual for portable Geiger counters — most operate from 90 volts. The question of battery replacement has been asked more than once. I simply picked a typical query and extended its range to cover the most popular high-voltage batteries of that era. If a reader wants a single voltage, it's easy enough to hardwire the respective resistor in place and remove the switch along with the unwanted resistors. — TJ*

It is with heavy hearts we must report that long-time NV columnist TJ Byers passed away in the wee hours of January 11th. He will be greatly missed.

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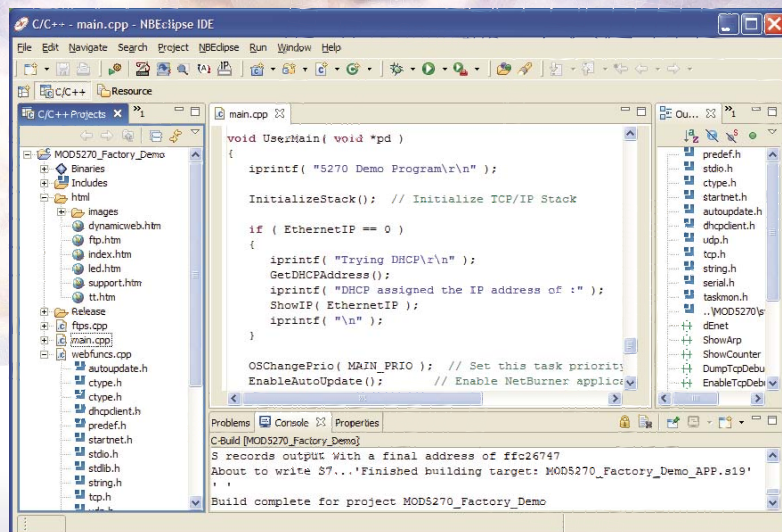
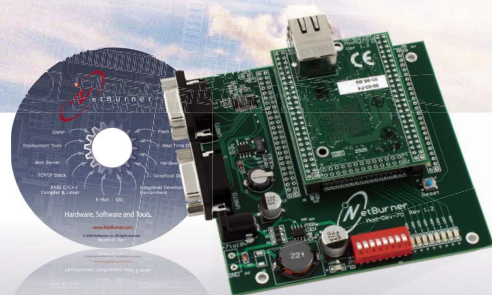
Debbie Stauffacher

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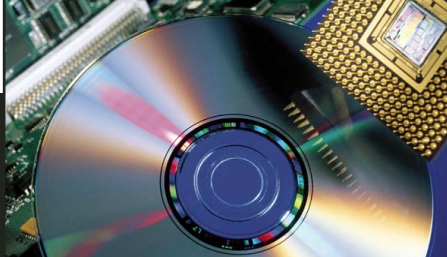
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■ BY JEFF ECKERT

ADVANCED TECHNOLOGY

FOOLING AROUND WITH AURORA

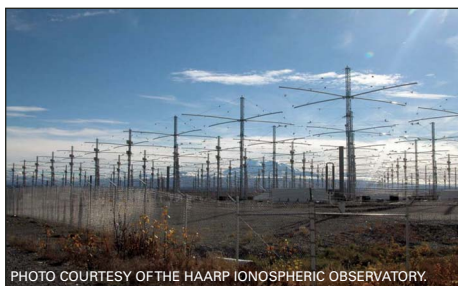


PHOTO COURTESY OF THE HAARP IONOSPHERIC OBSERVATORY.

■ The HAARP array includes 180 antennas spread out over 33 acres.

If you take Interstate A1 out of Anchorage, AK, and head a couple hundred miles to the northeast, you will encounter the town of Gakona, which is just a stone's throw from the Wrangell Saint Elias National Park. Even though the population was only 215 when the last census was taken, it is a pretty interesting place, being home to the High Frequency Active Auroral Research Program (HAARP, www.haarp.alaska.edu).

Jointly managed by the Air Force Research Laboratory and the Office of Naval Research, HAARP is scheduled to come fully online this year, and it has two main purposes. First of all, it has a suite of scientific instruments (receivers, magnetometers, radars, etc.) that allow researchers to perform passive observations of natural auroral activity to better understand the phenomenon. Second, one can fire up the ionospheric research instrument (IRI), which is a high-power HF transmitter system used to stimulate small areas of the ionosphere at an altitude between 100 and 350 km. The IRI will stir up a volume of a few hundred meters by a few tens of kilometers in diameter, allowing for various scientific studies.

As of this writing, only 48 antennas are operational, and the transmitter can generate just 960 kW

over a frequency range of 2.8 to 10 MHz. However, when complete, it will be able to pump about 3,600 kW into the full arsenal of 180 antennas. Observers on the ground won't be seeing any artificial aurora, though, as the signal strength in the target area is less than 3 W per square centimeter, which is tens of thousands times less than what the Sun delivers.

As a sideline, HAARP will be experimenting with extremely low frequency (ELF) signal generation techniques with an eye toward things like submarine communications. The facility has no regular visiting hours, but you can take a virtual tour at www.haarp.alaska.edu/haarp/tour.html.

RADAR PENETRATES POLAR ICE

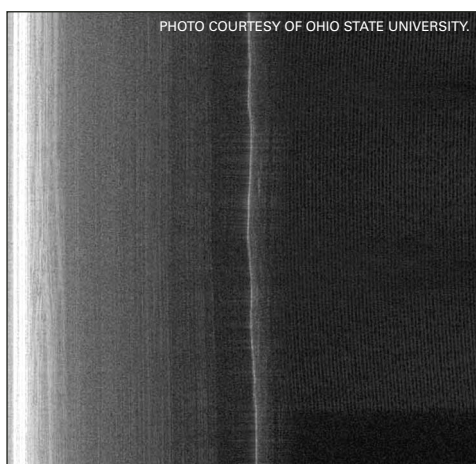


PHOTO COURTESY OF OHIO STATE UNIVERSITY.

■ Radar signal of subglacial Greenland topography obtained by GISMO.

It is known that the land beneath the Earth's ice sheets — which make up about 15 percent of the planet — can run the gamut from areas that have been scraped flat by moving ice to mountainous terrain and possibly lakes and rivers. But it has been very difficult to study the subglacial surface, because a lot of it has been covered with ice for close to three

million years, and existing radar systems are not all that good at mapping it out; they can only generate two-dimensional profiles over very narrow paths.

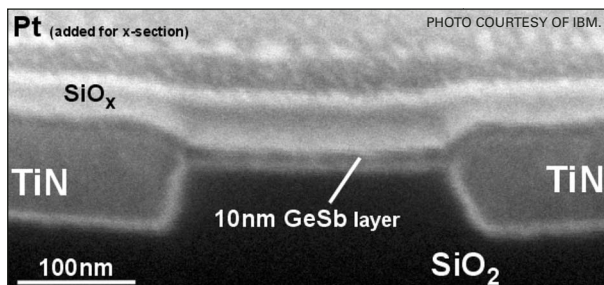
However, some scientists at Ohio State (www.osu.edu) have devised the Global Ice Sheet Mapping Orbiter (GISMO), a system that uses multiple steerable antennas mounted on an airplane to obtain three-dimensional images over a mile-wide strip, at depths 1.2 miles beneath the ice surface.

The system uses vertical and horizontal radar elements to generate an interference pattern, and computer techniques are under development that will increase the radar's ability to use that pattern to cancel out the effects of surface ice. The first experiment involved peeking under Greenland's ice and produced the image shown. Although the image isn't exactly equivalent to a good topo map yet, the left half of the image does reveal the vertical layers of ice from the surface down to the base (white line, center), and the right half shows a horizontal view of the topography.

As signal processing techniques are improved, the images should get better and become useful for monitoring the effects of climate change on the ice and water beneath it. It is projected that the concept could one day operate from a satellite to study more of the world or even other planets. The next trip over Greenland is scheduled for April, so stay tuned.

NEW MEMORY TECHNOLOGY DEMONSTRATED

Late last year, scientists at IBM (www.ibm.com), Macronix (www.mxix.com.tw), and Qimonda (www.qimonda.com) announced some joint research that resulted in a new type of memory, dubbed "phase-change."



■ Cross-section micrograph of the phase-change memory bridge.

Judging by the prototype, it can switch 500 times faster than Flash while using half the power to write to a data cell. Its cross section is just 3 by 20 nm, equivalent to the chip industry's target for the year 2015 and considerably smaller than Flash memory's apparent downward limit of 45 nm (below which it is no longer nonvolatile).

At the heart of phase-change memory is a chunk of a semiconductor alloy that can be changed rapidly between an ordered, crystalline phase having lower electrical resistance to a disordered, amorphous phase with much higher resistance. Because no electrical power is required to maintain either phase of the material, phase-change memory is nonvolatile. It's premature to junk your hard drives and Flash memories, though, because a commercial version of the prototype is probably several years away.

COMPUTERS AND NETWORKING

CRAY BACK IN THE GAME?



■ Cray's new XT4™ supercomputer uses massively parallel processors to achieve peak performance of greater than one petaflops.

The history of Cray, Inc., stretches back to 1972, when founder

Seymour Cray — known as the “father of supercomputing” — founded Cray Research. The road has been bumpy, with mergers, spin-offs, the departures of key management, and a disastrous enough balance sheet that Cray stock was selling for

\$1.38 per share in 2005 (although it has recovered to around \$10 as of this writing). In the first nine months of last year, the company lost \$20.8 million on revenues of \$119.6 million. That, however, was better than the \$55.1 million loss during the same period in 2005.

In any event, Cray is predicting a profitable 2007, based largely on its new XT4 machine. Previously code-named “Hood,” it is derived from the XT3™ architecture, which uses massively parallel processing (MPP). The XT4 can be scaled up to as many as 30,000 AMD Opteron processors and provide better than one petaflops of performance (yes, that's 1,000,000,000,000 floating point operations per second).

The company seems to be back on track in the sales department as well, with announced orders from Oak Ridge National Lab, the National Energy Research Scientific Computing Center, and the Finnish IT Center for Science. The system is currently equipped with dual-core processors, but it is designed to be easily upgraded to quad-core chips. If you are interested in the technical details, just visit www.cray.com/products/xt4/. But unless you have a DoD-sized wallet, it will probably be sufficient to know that the XT4 achieves its performance and scalability with the help of its SeaStar2™ interconnect chips, through which the processors communicate.

This is superior to the cluster architecture in which many processors share a common interface. The machine represents the first product in the Rainier program, which is the first phase of its forward-looking Adaptive Supercomputing concept.

META-SEARCH MINES THE DEEP

You may have noticed an interesting phenomenon in which your

Internet searches turn up the same relatively useless results regardless of what search engine you use. This occurs because typical search engines for the most part troll only what is termed the “surface web” and ignore the “deep web,” which includes accessible but not easily spidered material such as graphic files, searchable databases, and other useful sources of information.

The solution is to go deep using a meta-search engine, which is an entity that performs a search of other searches and consolidates the results. There are several out there, but a good starting point is **IncyWincy.com**, a showcase site offered by Loop Improvements LLC to demonstrate its Net Research Server (NRS).

IncyWincy has spidered and indexed some 150 million pages plus hundreds of thousands of search engines, and you can even refine your search to turn up only web pages, forms, or images. It also includes a directory in case you want to look in general subject areas. If Google and Yahoo! let you down, give it a try.

FLASH IN THE PAN?



■ These USB drives come in several flavors.

The folks at **Dynamism.com** are dedicated to marketing innovative consumer technology from Japan and other regions, and they tend to focus on notebooks, digital cameras, PDAs, and so on. But with all due respect, I must bestow upon them the award for bringing forth this month's Most Ridiculous Product. Consider Sushi Disk, a collection of hand-built USB drives that are made to look like a piece of sushi. Among the choices are futomaki (large roll, 256 MB, \$99), otoro (fat tuna, 1 GB, \$219), mentai (pickled cod roe,

256 MB, \$119), and kanitumi (fried crab claws, 256 MB, \$119). And if all this sushi leaves you thirsty, try the bottle of sake (256 MB, \$99). Personally, I'm waiting until the bratwurst with kraut drives come out of Germany.

CIRCUITS AND DEVICES

SOLAR CELLS HIT 40+ PERCENT EFFICIENCY



■ A technician at Spectrolab examines an earlier version of the concentrator receiver assembly containing the solar cells. A triple-junction terrestrial concentrator solar cell is shown in the inset photo. PHOTO COURTESY OF SPECTROLAB, SUBSIDIARY OF BOEING.

Representing another step forward in solar cell technology, Spectrolab, Inc. (www.spectrolab.com), recently announced that — using concentrated

INDUSTRY AND THE PROFESSION

NANOTECH COMPETITION SCHEDULED

It was recently announced that Oak Ridge National Laboratory researcher Thomas Thundat has been elected a fellow of the American Association for the Advancement of Science (AAAS). Thundat, a member of the Biosciences Division at the Department of Energy lab-

oratory and a UT-Battelle corporate fellow, is noted for research involving sensor technology and weapons detection. The AAAS Council cited Thundat's "pioneering work in developing a novel class of sensors for molecular recognition using nanomechanical sensor platforms." One of his cited concepts uses microcantilever technology to detect minute amounts of TNT, which could be applied to both national security missions and the reclamation of former battlefields and war zones. Congrats!

These cells use essentially the same technology as the company's space-based cells, so they can be manufactured in high volumes within a reasonable period of time. Researcher Dr. Richard R. King commented, "These results are particularly encouraging, since they were achieved using a new class of metamorphic semiconductor materials, allowing much greater freedom in multijunction cell design for optimal conversion of the solar spectrum. The excellent performance of these materials hints at still higher efficiency in future solar cells."

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■ ORNL's Thomas Thundat.

Spectrolab's terrestrial concentrator cells are already generating power in a 33-kilowatt full-scale concentrator system in the Australian desert. The company recently signed multimillion dollar contracts for its high efficiency concentrator cells and is anticipating several new contracts in the next few months.

CD/DVD REPAIRS MADE EASY



■ The Aleratec Disc Repair Plus. PHOTO COURTESY OF ALERATEC, INC.

While Aleratec (www.aleratec.com) is perhaps better known for its duplication equipment, the word on the street is that its Disc Repair Plus actually works. It is billed

as a "patented, motorized system that can repair and clean up to 99 percent of all scratched DVDs, CDs, Game Discs, VCDs, DVD+Rs, DVD-Rs, DVD+RWs, DVD-RWs, CD-Rs, CD-RWs, and masters ... without the hassle that comes with a manual cleaning kit." The unit comes with three sets of wheels, one each for repair, cleaning, and buffing. You just drop the disc into the machine, add three drops of repair solution on the wheel, and it does the rest. At a list price of \$44.95, it won't take too many repairs for it to pay for itself. **NV**

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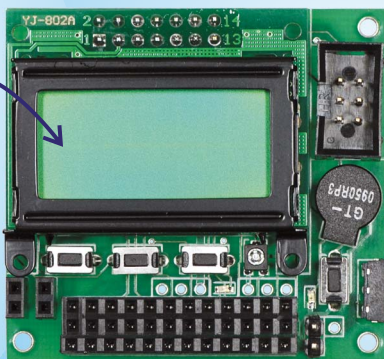
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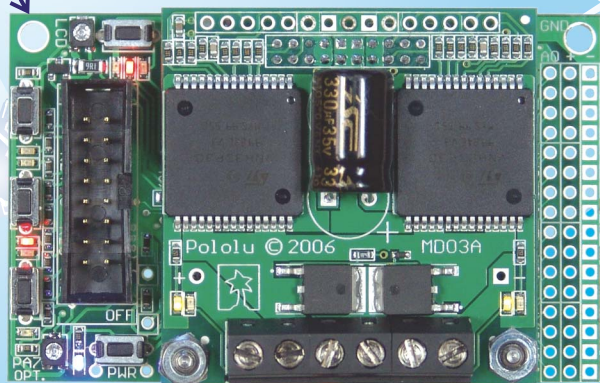
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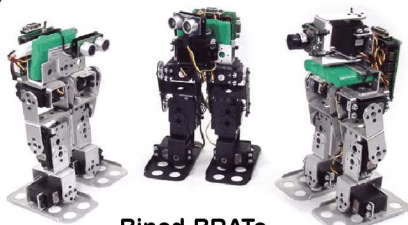
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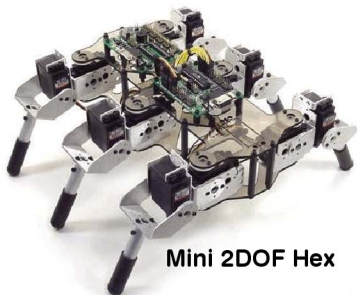
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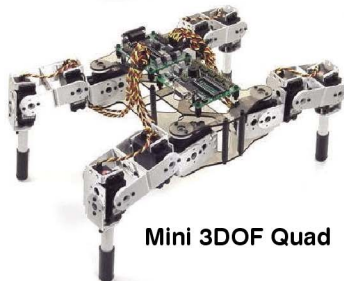
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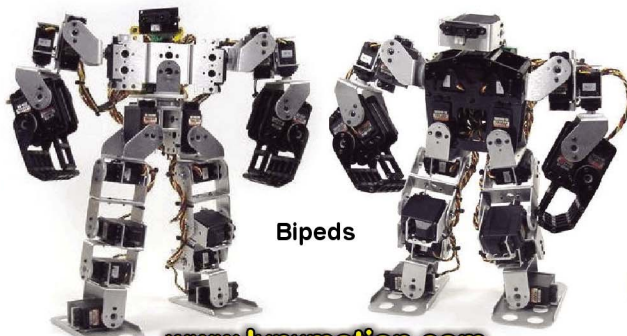
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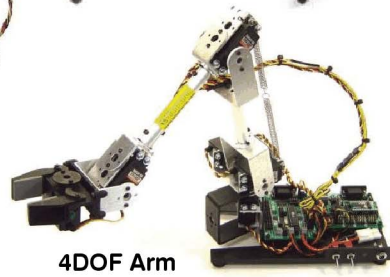
Round 3DOF Hex



Mini 3DOF Quad



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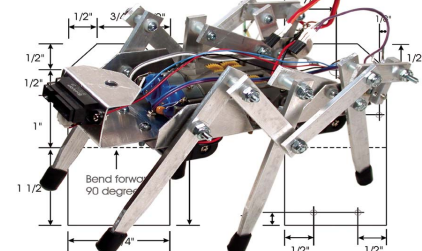


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■ BY PHIL DAVIS

MOTOR TEST LAB — PART 2

LAST MONTH, I WENT OVER THE PROCESS of constructing my homemade Motor Test Lab. Since then, I made a couple of changes to the basic design before using it to test a couple of motors.

The first change I made was to add a block connector and a switch at the power output stage. The connector made it easier to connect and disconnect motors. The switch allowed me to disconnect the motor during testing which was a favor to the dogs and my wife as they had gotten extremely tired of listening to the audible whine of the 8K PWM (pulse width modulation). Please see Photo 1.

The second change I made was some slight alterations of the code required to convert the RC-style PWM into the H-bridge style PWM. Please see Listing 1.

WHAT CAN THE MOTOR TEST LAB MEASURE?

Because we are using Power Analyzer Pro — a commercial off-the-shelf product integrated into our lab — we are relying heavily on its capabilities. As I mentioned in Part 1, this device was created for the RC marketplace where it is used to measure the parameters of high-performance RC Flight DC motors. We have changed its mission somewhat, but all its capabilities are no less valid.

The Power

Analyzer Pro has a large set of features, but those which I personally am interested in for my robotic projects are:

- Voltage measurement
- Current measurement
- RPM
- Torque

The Power Analyzer Pro also has the ability to connect to your PC. If you use this feature, then you will have the ability to control the motor 'remotely' and graph some of the above measurements.

PREPARING A MOTOR FOR TEST

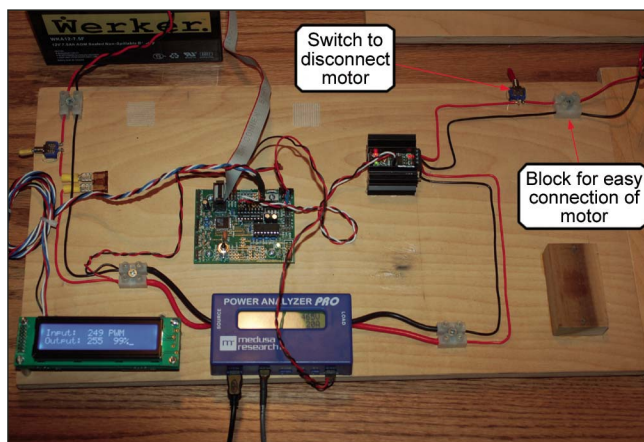
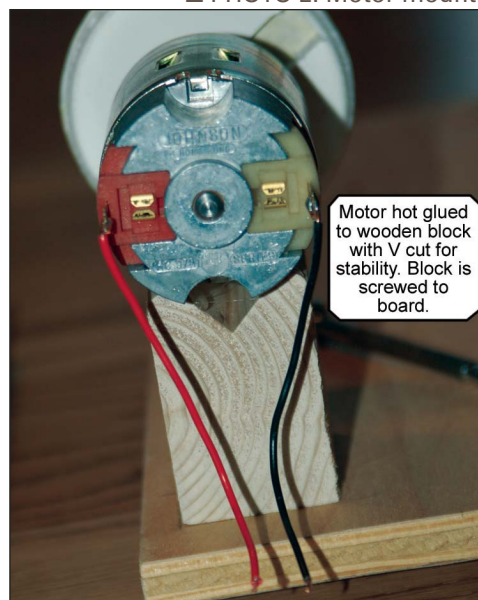
One of the motors I am going to test is one I picked up for \$6 at my local surplus store. When I bought this motor, I knew absolutely nothing about it except its size —

three inches long and two inches in diameter — plus the fact that when I turned the output shaft, I could feel strong cogging.

Okay, the first thing I want to do is make sure I have a secure mount for the motor. As you can see from the photos, I constructed the test system on top of some plywood, which is available to everyone and easy to work with. The motor is mounted to a separate board and placed on top of a small wooden block with a 'V' cut into it for stability, as in Photo 2. I hot glued the motor to the block to keep it rigid and make it easy to take off.

One of the parameters I want to measure is RPM. The Power Analyzer Pro comes with an IR emitter/receiver pair which is used to measure the

■ PHOTO 2. Motor mount.



■ PHOTO 1. Changes since last month.

LISTING 1. RC to H-bridge Conversion.

```
//-----
// Function: Int 0 interrupt handler
// Action: Used to measure a 1-2ms input pulse
// Comment: A smoothing filter might make this work a little better
//          eg. a 4 or 5 length moving average
//-----
SIGNAL (SIG_INTERRUPT0)
{
    if(PIND & 0x04) { // is pin high
        PulseWidth_Start = TCNT2; // get start of time period
    } else {
        PulseWidth_End = TCNT2; // get end of time period
        if(PulseWidth_Start > PulseWidth_End) {
            RC_Width = (0xff - PulseWidth_Start) + (PulseWidth_End);
        } else {
            if(PulseWidth_End > PulseWidth_Start) {
                RC_Width = PulseWidth_End - PulseWidth_Start;
            }
        }
    }

    // RC_Width will now have a range of 128 - 255 (in theory)
    Width_raw = RC_Width; // get for debug purposes

    if (RC_Width > 248) // bump to compensate for timing
        RC_Width = 255; // this gives full power
    else
        RC_Width_bias = RC_Width + 4; // bump to compensate for timing

    if (RC_Width < 128) // clip as timing may be off slightly
        RC_Width = 128;

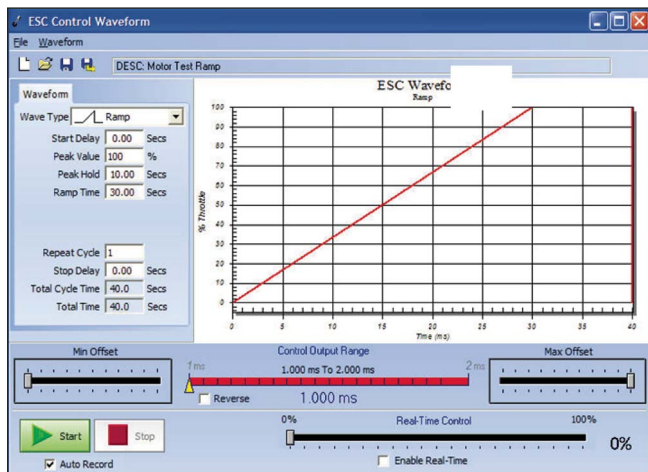
    RC_Width_base = RC_Width - 128; // scale to 0 - 128, for debug purposes
    RC_Width_cpy = RC_Width_bias; // make copy for use in 'tasks'.
}
```

RPM of an RC plane's propeller. The obvious trick here is to make an encoder disk and glue it to the motor shaft, then mount the emitter/receiver close to the surface so the lines can be read. I drew up an encoder disk in

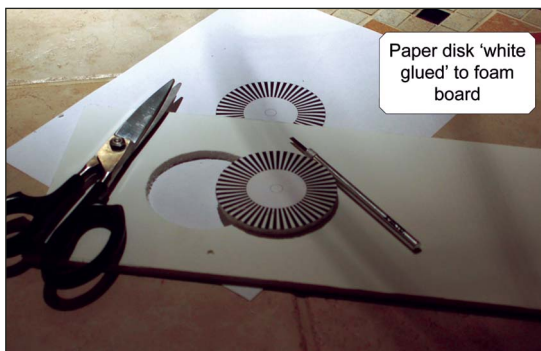
a drawing program, glued it to some poster board with white glue, and then used the same glue to mount it on the shaft. Check out Photo 3.

TESTING THE MOTOR

■ PHOTO 4. 'Run' profiles for testing.



So that's it. The motor is mounted on its own board with an



■ PHOTO 3. Making the encoder disk.

encoder disk and is ready to test. The PC computer interface for the Power Analyzer Pro allows the user to create a 'Run' with which you can specify a variety of test profiles, as shown in Photo 4. On the 'Waveform' tab, you will notice that I have chosen a simple linear ramp with the following parameters: No start delay, a peak value of 100% (which is full speed), holding the peak value for 10 seconds, and specifying that the ramp will take 30 seconds. It is possible to choose other waveforms, as in Photo 5.

When we execute this Run profile, PWM will be fed to the motor such that the PWM follows the graph in Photo 4, gradually increasing until the motor is running at 100% and then holding there for a period.

During the Run, in real-time, a graph will be drawn of all the measurements we have chosen. Power Analyzer has a tool with which you set your dials, gauges, and graphs, but I won't be going into detail on that setup. However, looking at Photo 6, you can see the output I was getting.

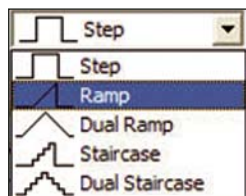
Let's try and do a brief analysis of the various lines in the graph. The gray line represents the linear throttle response, which is actually

a steady increase in PWM (and consequently voltage) and, as you can see, it follows the programmed profile.

The purple line is the actual measured RPM from the encoder disk. I should note that the analyzer application has the ability to massage the data coming in and, in this case, the RPM in is automatically divided by the number of lines on the encoder disk, divided by two. This produces

the correct RPM value as the analyzer believes it is using a two-bladed propeller.

One thing to note



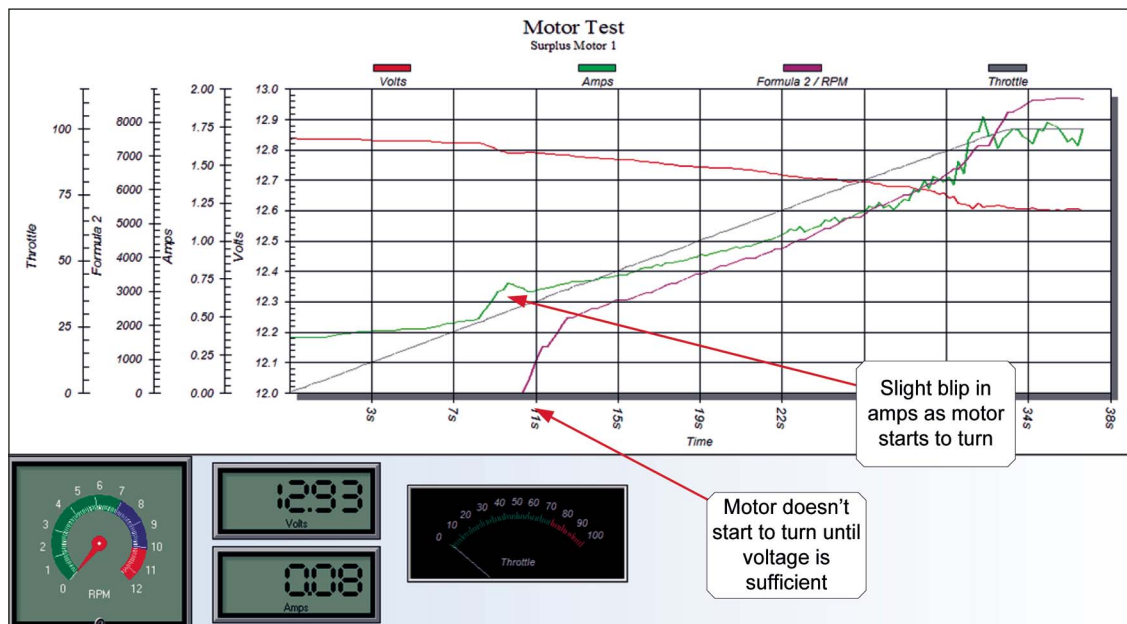
■ PHOTO 5. Waveform selections.

from the graph is that the motor does not start turning until around nine or 10 seconds into the test, which is where sufficient voltage has built up from the PWM. The purple RPM line continues on to a maximum of around 8,300 RPM.

The green line represents the amps required to run the motor. As you can see, it starts right off at about .3 amps and slowly climbs until the motor just starts to turn, at which point there is a blip, after which it steadily climbs to a max of around 1.6 amps.

The red line represents the voltage from the battery. As the RPM and amps increase, the voltage from the battery drops in concert, starting off at 12.85 and dropping to around 12.6.

A couple of additional points to note: Once the motor starts turning (represented by the purple RPM line) it tracks (is proportional to) the voltage which, in this case, is the gray throttle line. This is a characteristic of a DC motor. Up near the top of the graph at close to 100% throttle, you can see all the measured inputs getting very bouncy and jagged. I would surmise that this is because the magnetic fields are breaking down in the windings, but I am not a DC motor expert.



■ PHOTO 6. Real time 'run' graph.

comes with an electronic scale which would normally be used to measure the thrust of a spinning propeller; useful I guess, if you want to know if you have sufficient thrust to fly. But in our case, we have no propeller and we really want to measure torque.

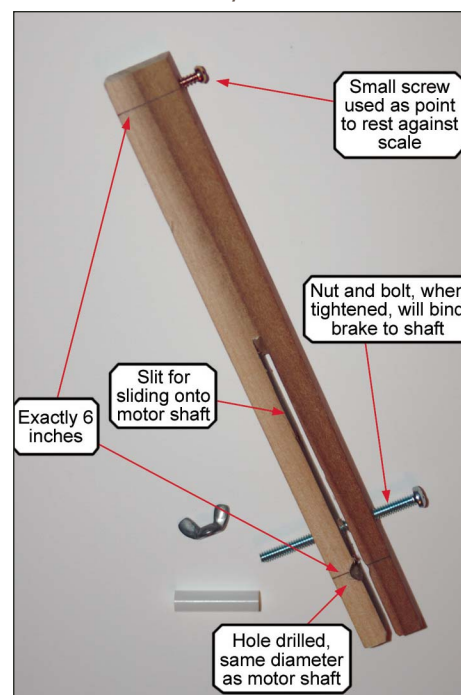
The Internet and the advice from a friend are wonderful things. After much searching, I came across a device called a "Prony Brake" which was developed by French mathematician Gaspard de Prony (1755-1839) and can, in fact, measure torque. To keep things simple and in line with the rest of the construction, I made my Prony Brake out of wood, which you can see in Photos 7 and 8.

The construction is fairly straightforward; a hole the same diameter of the motor shaft is drilled through a piece of wood and at exactly six inches from that on the other side (other plane), a small screw is partially screwed in. A saw cut is made though the shaft hole, extending quite far

down the wood. (You will need to look at the pictures to understand this). A small hole is then drilled through the wood on the same plane as the screw, for a bolt, spacer, and wing nut.

The operation of the Prony Brake is as follows: Open the wing nut so it is very loose. Slide the slit in the wood over the motor shaft until the shaft clicks into the pre-cut hole and then loosely tighten the wing nut; not so tight though that the brake does not freely rotate on

■ PHOTO 7. Prony Brake construction.

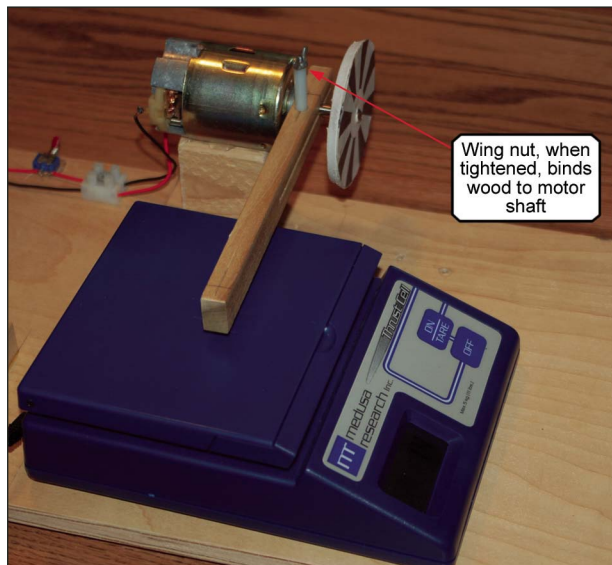


WHAT ABOUT TORQUE?

All right, one last parameter to measure: Torque. The Power Analyzer Pro

■ PHOTO 8. Prony Brake assembled with scale.





■ PHOTO 9. Prony Brake on motor, resting on the scale.

10. Believe it or not, in this photo the encoder disk is spinning at 5,000 RPM and my camera froze it. In any case, the reading on the scale is 1.5 oz and, in actual fact, it varied around the 1.5-1.6 mark.

What does this mean? Well, we made our Prony Brake so the distance between the shaft and the screw which rests on the scale was as close as possible

to six inches. This being the case, we can now multiply the ounce value by the length, $1.5 * 6$ to arrive at the torque in oz-ins. This motor was developing 9 oz-ins at 5,000 RPM.

In addition, a quick glance showed the amperage measurement to be 4.5. I also very briefly cranked down the Prony Brake until the motor stalled and checked the amperage. These values tell us what the minimum size of H-Bridge is that I needed.

Because the Prony Brake has to be cranked down by hand, creating a graph is not something that can be done automatically. Nevertheless, it is not difficult to make half a dozen tests at different RPM values, recording the amperage and torque for each one.

SO, HOW DOES THIS MOTOR MEASURE UP?

the shaft. Position the scale such that the screw rests in the center of the scale and reset the scale to accommodate the weight of the wood. Now you're ready to go. See Photo 9 for this setup.

MEASURING THE TORQUE

With a bit of luck, everything should be set up to measure the torque. You could do this a number of ways, but I used the "Real Time Control" slider on the application to run up the motor to max RPM — full speed. I then tightened up the wing nut on the Prony Brake so that it started to bind on the motor shaft and, at the same time, kept an eye on the RPM. When the RPM reached 5,000, I looked at the ounce reading on the scale. Please see Photo

am looking for a motor which will run a robot, perhaps something like a robot for the Magellan contest. My first thoughts are that the bot should not go tearing across a field at break neck speed.

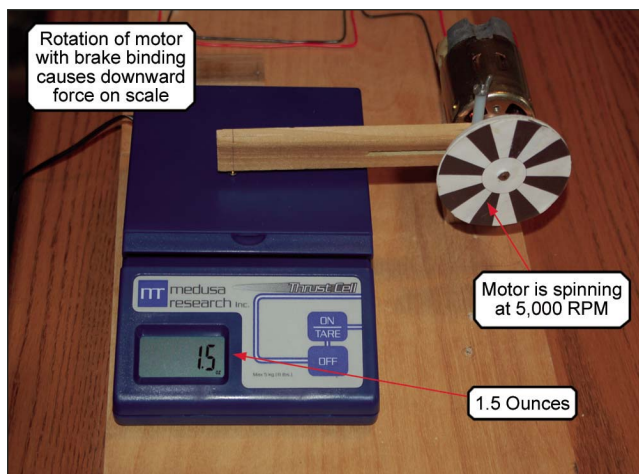
Well, what do I want? Let's begin by trying to reverse-engineer this. An average person walks at around three miles per hour which works out to be about four feet per second ($(3 * 5280)/60/60$). That seems like a good speed, but let's go a bit faster and assume the bot's max speed will be 1.5 times that at six feet per second (a fast walk).

Now, let's assume we have six-inch diameter wheels. This will mean a wheel will travel about 18 inches in one revolution ($6 * \pi$). If we want to go at six feet per second, how many revolutions must we make per second ($6/(18/12)$)? This is four. In summary, this means for our bot to travel at the maximum specified speed of six feet per second, the wheels will have to make four revolutions per second.

With this information, we can try and figure out if the motor will fit our needs when properly geared. A lot of this will be guess-work without very expensive equipment with which to make precise measurements, but we can get a feel for what should work.

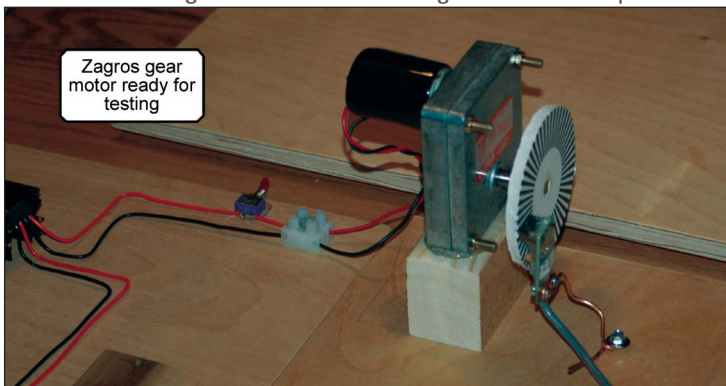
Let's assume to gear our motor, we use timing belts, chains or gears which are from about 60-90% efficient (respectively). The next thing to consider is what happens to the RPM of the motor under load. The load, in this case, will be the torque required to move the rolling weight of our bot and, in a worst case, perhaps

■ PHOTO 10. Torque reading.



Good question! I

■ PHOTO 11. Zagros Robotics Max 96 gear motor setup.



up a slight gradient. This is where we would need to make lots of empirical measurements (perhaps), so let's make a guess at this and say an RPM degradation of 50%.

Now we can say that the effective RPM of our motor will be 80% of 8,300 RPM and then 50% of that. This will be our max usable RPM and calculates out at 3,320 or 55 per second, and dividing this by our required revolutions per second, we have a needed gear ratio of 55/4 or 13.8. We round that off to 14; and this is the ratio we will use for gearing the motor.

We might also suggest a final torque value at the wheel by multiplying the motor shaft torque by 14, this gives 9*14 oz-ins or 126 oz-ins. At the circumference of the six-inch wheel in pounds, this would be 126/3/16 which is 2.65 pounds (the 3 in the formula is the radius). If you were to use two motors (differential steering), you might have around five pounds of force; not bad for a small bot. I hope this makes sense.

TESTING A SECOND MOTOR

I'm not going to bore you with all the details of testing a second motor, so I will go through some of the highlights. The second motor I tested was a geared motor I got from Zagros Robotics, called the Max 96/99/97.

RESOURCES

■ *Medusa Research Power Analyzer* — www.medusaproducts.com

■ *Matrix Orbital LCD* — www.matrixorbital.com

■ *Zagros Robotics gear motor* — www.zagrosrobotics.com

■ *Electronics Exchange surplus motor* — www.electronics-exchange.com

■ *FreeRTOS* — www.freertos.org/

■ *WinAVR* — <http://winavr.sourceforge.net/>

■ *AVRstudio* — www.atmel.com/dyn/products/tools_card.asp?tool_id=2725

You can go to the website and read the specs on this motor. See Photo 11 for this setup.

The testing of this motor went very well and to highlight some of the details:

- Measured max RPM was about 20 to 25 RPM.
- Amps went from about .1 to .2 at max speed (unloaded).

SUMMARY

With a little effort and some off-the-shelf products, the hobbyist should be able to build a Motor Test Lab/Dynamometer which rivals multi-thousand dollar versions. In any case, you have to do something to understand the motors you are using if you get them at surplus suppliers, perhaps just wet your finger and stick it in the air. **NV**



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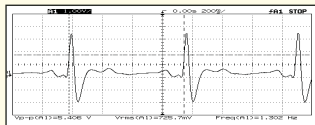
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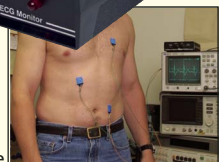


February is the month for Valentine's Day, and what a great time to think of your heart! Not how many times it's been broken, not how many times it's fallen head over heels in love, but how it actually works...and how it's doing these days!

Use the ECG1C to astound your physician with your knowledge of ECG/EKG systems. Enjoy learning about the inner workings of the heart while, at the same time, covering the stage-by-stage electronic circuit theory used in the kit to monitor it. The three probe wire pick-ups allow for easy application and experimentation without the cumbersome harness normally associated with ECG monitors. The documentation with ECG1C covers everything from the circuit description of the kit to the circuit description of the heart! Multiple "beat" indicators include a bright front panel LED that flashes with the actions of the heart along with an adjustable level audio speaker output that supports both mono and stereo hook-ups. In addition a monitor output is provided to connect to any standard oscilloscope to view the traditional style ECG/EKG waveforms just like you see on ER... or in the ER! See the display above? That's one of our engineers, hooked up to the ECG1C after an engineering meeting!

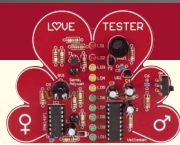
The fully adjustable gain control on the front panel allows the user to custom tune the differential signal picked up by the probes giving you a perfect reading and display every time! 10 hospital grade re-usable probe patches are included together with the matching custom case set shown. Additional patches are available in 10-packs. Operates on a standard 9VDC battery (not included) for safe and simple operation. Note, while the ECG1C professionally monitors and displays your heart rhythms and functions, it is intended for hobbyist usage only. If you experience any cardiac symptoms, seek proper medical help immediately! (Like I did after I got the ad deadline date for February from Robin!)

ECG1C	Electrocardiogram Heart Monitor Kit With Case & Patches	\$44.95
ECG1WT	Electrocardiogram Heart Monitor, Factory Assembled & Tested	\$89.95
ECGP10	Electrocardiogram Re-Usable Probe Patches, 10-Pack	\$7.95



Electronic "Love Tester"

- ✓ 10 LED love scale display!
- ✓ Audible love level sound!
- ✓ Great party fun!
- ✓ Heart shaped PC board!



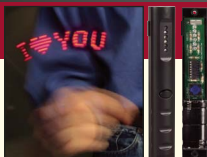
This uniquely shaped "Love Tester" is the ultimate gag for any couple! Designed to check your love life, each partner holds one end of the tester PCB at the appropriate male and female touch pads. Then they romantically join hands and watch the results on the love meter! 10 green, yellow, and red LEDs act like a scale, and just like the carnival when it hits the top they flash, indicating you're a red hot couple! There is also an audible alarm that changes with the "love level". Next time the party isn't going anywhere, bring this out, it's a riot!

Wide sensitivity range is compatible with all couples. Includes a built-in power on/off switch. Runs on a standard 9V battery. Measures 4.1" x 3.1" x .98".

MK149	Electronic Love Tester Kit	\$16.95
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LED Magic Message Wand

- ✓ Message floats in air!
- ✓ Fun at concerts & events!
- ✓ High visibility red LEDs
- ✓ Pre-programmed or custom messages



Use the "Magic Wand" to display your true feelings! Simply shake it back and forth and brilliant messages seem to appear in mid-air! Six high intensity LEDs are microprocessor controlled to display messages and graphics that are pre-programmed into the wand.

You can also custom program a message of your choice! From amazing your friends, making a statement at a concert, or simply telling your loved one how you feel, the message wand can't be beat!

Runs on two AAA batteries (not included), and the auto power off circuit gives you long battery life. Measures 6.4" x 1" x .9".

MK155	LED Magic Wand Kit	\$16.95
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SMT LED Flashing Heart Pin

- ✓ Use it as a pin or pennant!
- ✓ 2 brilliant blue LEDs
- ✓ 3 brilliant red LEDs
- ✓ Magnetic pin attachment



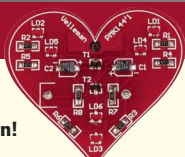
This .9" heart-shaped pin is sure to be an attention getter. 5 bright LEDs (2 blue, 3 red) flash brightly, guaranteed to elicit interest from anyone (or anything) attracted to shiny objects! Factory assembled and tested and ready to use.

The unique design can be hung as a pennant using the small hole at the top. But it gets even better, this little heart comes complete with a small but powerful magnet to "pin" it to your clothing...without any holes! Holds it in place and it can even be moved! Runs on two standard CR927 button cells (included) and turns on and off from the back. Show everyone how you feel about that special person in your life with this lively pin!

LFB3	SMT LED Flashing Heart Pin	\$2.95
------	----------------------------	--------

SMT LED Flashing Heart Display

- ✓ Alternating flashing!
- ✓ 6 super bright SMT LEDs!
- ✓ Learn all about SMT!
- ✓ Definitely gets her attention!



This cute little kit gives you a distinctive red display using 6 Surface Mount (SMT) LEDs. The PC board is in the shape of a red heart. The small size makes it perfect to be used as a badge or hanging pendant around your neck. Even better as an illuminated attention-getting heart to accompany a Valentine's Day card!

Makes a great SMT learning kit to bring you into the world of SMT technology, design, and hands-on soldering and troubleshooting. Don't worry, extra SMT parts are included just in case you lose or damage any! Runs on a small CR2025 or CR2032 button cell (not included). Measures 1.9" x 1.7" x .3".

MK144	SMT LED Flashing Heart Kit	\$11.95
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Mini-Kits... The Building Blocks!

Tickle-Stick

The kit has a pulsing 80 volt tickle output and a mischievous blinking LED. And who can resist a blinking light! Great fun for your desk, "Hey, I told you not to touch!" Runs on 3-6 VDC



TS4	Tickle Stick Kit	\$12.95
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Super Snoo Amplifier

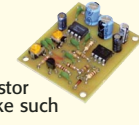
Super sensitive amplifier that will pick up a pin drop at 15 feet! Full 2 watts output. Makes a great "big ear" microphone. Runs on 6-15 VDC



BN9	Super Snoo Amp Kit	\$9.95
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Dripping Faucet

Produces a very pleasant, but obnoxious, repetitive "plink, plink" sound! Learn how a simple transistor oscillator and a 555 timer can make such a sound! Runs on 4-9 VDC.



EDF1	Dripping Faucet Kit	\$9.95
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LED Blinky

Our #1 Mini-Kit for 31 years! Alternately flashes two jumbo red LED's. Great for signs, name badges, model railroading, and more. Runs on 3-15 VDC.



BL1	LED Blinky Kit	\$7.95
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Cricket Sensor

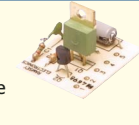
Senses temperature and changes the chirp accordingly. Can actually determine temp by chirps! Runs on 9VDC battery. Speaker included.



ECS1	Cricket Sensor Kit	\$24.95
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Electronic Siren

Produces the upward and downward wail of a police siren. Produces 5W output, and will drive any speaker! Runs on 6-12 VDC.



SM3	Electronic Siren Kit	\$7.95
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Universal Timer

Build anything from a time delay to an audio oscillator using the versatile 555 timer chip! Comes with lots of application ideas. Runs on 5-15 VDC.



UT5	Universal Timer Kit	\$9.95
-----	---------------------	--------

Voice Switch

Voice activated (VOX) provides a switched output when it hears a sound. Great for a hands free PTT switch, or to turn on a recorder or light! Runs on 6-12 VDC and drives a 100 mA load.



VS1	Voice Switch Kit	\$9.95
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Tone Encoder/Decoder

Encodes OR decodes any tone 40 Hz to 5KHz! Add a small cap and it will go as low as 10 Hz! Tunable with a precision 20 turn pot. Runs on 5-12 VDC and will drive any load up to 100 mA.



TD1	Encoder/Decoder Kit	\$9.95
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RF Preamplifier

Super broadband preamp from 100 KHz to 1000 MHz! Gain is greater than 20dB while noise is less than 4dB! 50-75 ohm input. Runs on 12-15 VDC.



SA7	RF Preamp Kit	\$19.95
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Touch Switch

Touch on, touch off, or momentary touch hold, your choice! Uses CMOS technology. Runs on 6-12 VDC and drives any load up to 100 mA.



TS1	Touch Switch Kit	\$9.95
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What's Hot for 2007!

The Newest And Neatest Goodies

Passive Aircraft Airband Monitor

- ✓ Monitors the entire aircraft band without tuning!
- ✓ Passive design, can be used on aircraft, no local oscillator, generates and creates no interference!
- ✓ Great for air shows
- ✓ Patented circuit and design!

For decades we have been known for our novel and creative product designs. Well, check this one out! An aircraft receiver that receives all nearby traffic without any tuning. It gets better... there is no local oscillator so it doesn't produce, and can't produce, any interference associated with all other receivers with an LO. That means you can use it onboard aircraft as a passive device! And what will you hear? The closest and strongest traffic, mainly, the one you're sitting in! How unique is this? We have a patent on it, and that says it all!

This broadband radio monitors transmissions over the entire aircraft band of 118-136 MHz. The way it works is simple. Strongest man wins! The strongest signal within the pass band of the radio will be heard. And unlike the FM capture effect, multiple aircraft signals will be heard simultaneously with the strongest one the loudest! And that means the aircraft closest to you, and the towers closest to you! All without any tuning or looking up frequencies! So, where would this come in handy?

1. At an air show! Just imagine listening to all the traffic as it happens
2. Onboard aircraft to listen to that aircraft and associated control towers
3. Private pilots to monitor ATIS and other field traffic during preflight activities (saves Hobbs time!)
4. Commercial pilots to monitor ATIS and other field traffic as needed at their convenience
5. General aircraft monitoring enthusiasts

Wait, you can't use a radio receiver onboard aircraft because they contain a local oscillator that could generate interfering signals.

We have you covered on that one. The ABM1 has no local oscillator, it doesn't, can't, and won't generate any RF whatsoever! That's why our patent abstract is titled "Aircraft band radio receiver which does not radiate interfering signals". It doesn't get any plainer than that! Available as a through-hole hobby kit or a factory assembled & tested SMT version.

ABM1 Passive Air Band Monitor Kit **\$89.95**
ABM1WT Passive Air Band Monitor, Factory Assembled & Tested **\$159.95**

3-In-1 Multifunction Soldering Lab

- ✓ ROHS soldering station!
- ✓ Digital multimeter!
- ✓ Regulated lab power supply!
- ✓ Everything all in one unit!

Take a close look! On your left is a multi-function 3½ digit digital multimeter. Its large backlit LCD display can be seen from anywhere on your bench while you're working. The DMM also features built-in transistor, diode, and continuity testing, data hold, and audible alarm. Next up, the regulated lab DC power supply. Switch selectable ranges of 3V, 4.5V, 6V, 7.5V, 9V, and 12V provide a continuous duty current of 1.5 amps with a 2 amp peak! Features both overload protection and overload indication.

To the right we have a high quality temperature regulated soldering station. The 24V low voltage iron features an isolated ceramic 48 watt temperature controlled element. Front panel control gives you variable tip temperature control from 150°C to 450°C and LED indication of power-on and heating-on. Runs on 120VAC.

LAB1U 3-in-1 Multifunction Soldering Lab **\$119.95**



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- ✓ Pressure resolution greater than 0.0001kPa!
- ✓ 128 x 64 pixel graphical display!
- ✓ Shows realtime elevation & pressure changes!
- ✓ USB computer interface for easy data transfer!
- ✓ 13,824 samples of FLASH storage available!
- ✓ Special pilots menu
- ✓ Multiple built-in alarms



What The Customer's Are Saying... "Stunning!"

We really did it this time! The UP24 is one of our most advanced kits to date, and an absolute MUST for anyone serious about the environment around us. But the applications only begin there!

The unique design allows unprecedented super high resolution measurements and display of absolute atmospheric air pressure. The UP24 senses ambient air pressure and critically calculates elevation with unheard of precision! Using a highly sensitive sensor and 24-bit A/D converter in a special noise-immune design, less than 1/3" of an inch of elevation resolution is achieved! YES, we said 1/3 of an inch! This high accuracy and resolution opens the door to a host of sophisticated environmental air pressure monitoring applications.

Unlike your normal run-of-the-mill barometer, air pressure is sensed in Pa's or kPa's. What are those you may ask? Pascals or KiloPascals. However, don't be afraid, for your convenience, and to fit any application you may have, it is also displayed in millibars, bars, PSI, atmospheres, millimeters of mercury, inches of mercury, and feet of water! Take your pick! The range of the UP24 is 15kPa to 155kPa.

We've talked about air pressure, now let's talk about elevation! The incredibly precise 24 bit A/D converter in the UP24 looks at the air pressure and converts it to elevation above sea level. In both graph and text, the elevation is displayed to a resolution of 1/3"! Yes, I said 1/3 of an inch! The applications for the super accurate elevation meter are endless. From watching and recording elevations during hiking trips to measuring and recording the wave heights on boats! Let your imagination take over from there!

What if you're in the field and you want to save data captured in your UP24? The built-in FLASH storage provides 13,824 samples of storage. Then you can transfer your data to your PC with a standard USB interface.

While the UP24 is small enough to be kept in your coat pocket it boasts a large 2.78" x 1.53" 128x64 pixel LCD display screen making viewing easy. Display modes include both realtime pressure and elevation graphs as well as pressure and elevation statistics. There are 12 user selectable sample rates from 1/10th of a second all the way up to every 15 minutes. Includes a built-in NiMH battery pack for up to 4 days of continuous use. 110VAC charger is included. May also be charged from a 6-12VDC source.

Needless to say, you cannot put all the specs and screen shots in the limited space of this ad! Visit our website at www.ramseykits.com for full specs and information.

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Q&A

WHAT'S UP:

Hot chocolate, a warm fire, and a list of fun, one-night projects. What better way to while away winter?

WITH TJ BYERS

In this column, I answer questions about all aspects of electronics, including computer hardware, software, circuits, electronic theory, troubleshooting, and anything else of interest to the hobbyist.

Feel free to participate with your questions, comments, or suggestions.

Send all questions and comments to:

Q&A@nutsvolts.com



Sawtooth generator.



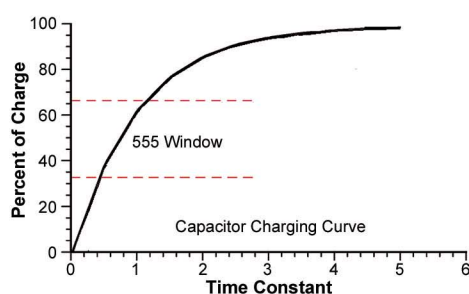
MIDI AB switch box.



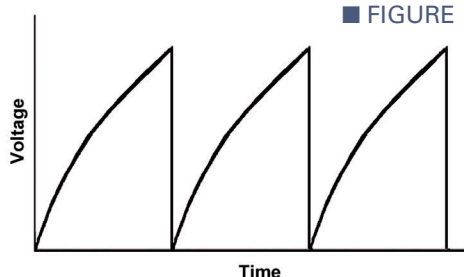
Phone transmitter key.



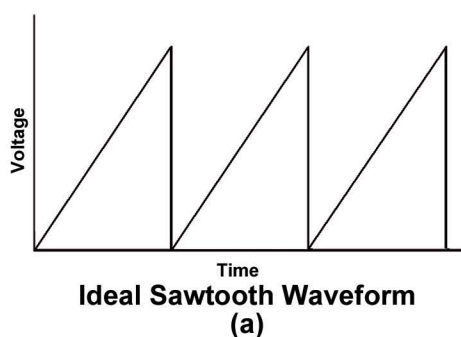
Model RR trolley controller.



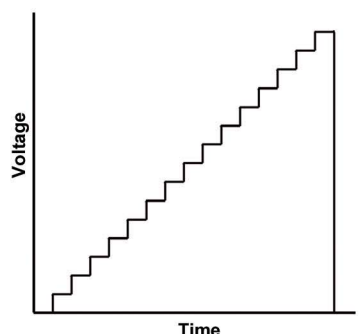
Capacitor Charging Curve
(b)



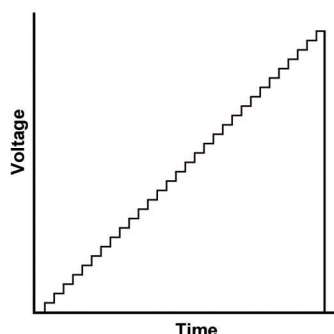
555 "Sawtooth" Waveform
(c)



Ideal Sawtooth Waveform
(a)



4-Bit Staircase Waveform
(d)



5-Bit Staircase Waveform
(e)

SAWTOOTH GENERATOR

Q Could you please show me how to make a variable-frequency sawtooth generator?

— A Devoted Reader

A You didn't say if you wanted a digital or analog circuit, so I will give you both. A sawtooth wave is characterized by a positive-going linear voltage ramp concluded with a sharp drop to zero (Figure 1a). One way to generate a sawtooth is to slowly charge a capacitor via a constant current source, then quickly discharge the capacitor by shorting it out. By repeating this process, a sawtooth waveform is created.

But constant-current sources can be complex — especially if you want to make it adjustable. In lieu of a constant current source, a fixed resistor is often used to limit the cap's charging current. However, the voltage across a charging capacitor using a fixed resistor isn't linear. It starts off fast and finishes slowly, creating the waveform you see in Figure 1b. But by selecting a section of the curve that is more or less linear —

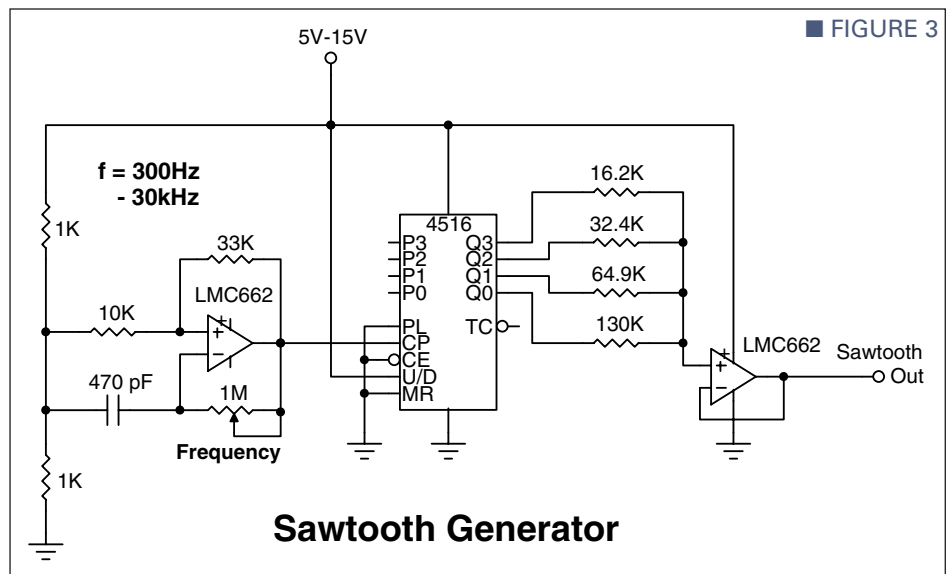
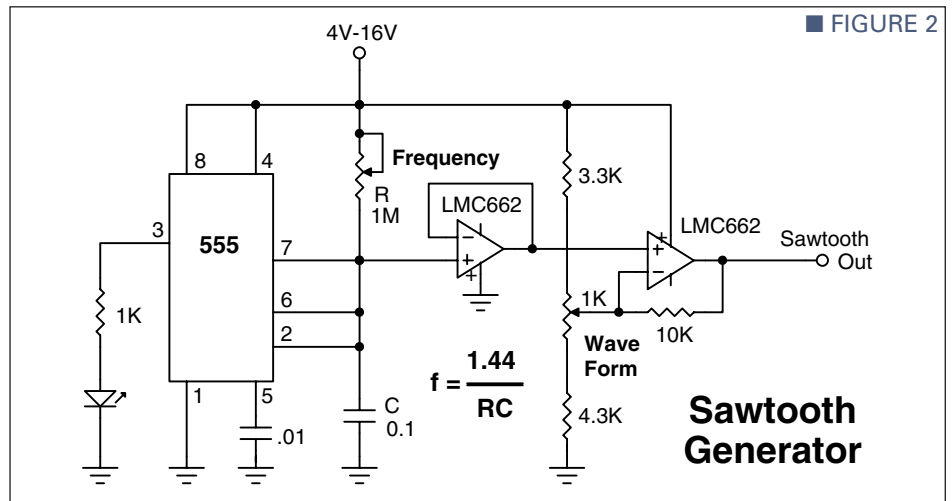
as shown by the red dashed lines – we can generate a pseudo sawtooth. A 555 timer is an astable oscillator that exploits the charging and discharging of a capacitor. It has its trip points – the points where the cap starts to charge and ends charging – at $1/3$ and $2/3$ the working voltage, creating the waveform shown in Figure 1c. Not perfect, but good enough for most electronics designs. The waveform is then buffered (Figure 2) and conditioned. The Frequency pot changes the frequency and the Wave Form control adjusts the wave to keep the top and bottom of the waveform from being clipped.

A more linear sawtooth waveform can be generated using a digital up counter with weighted outputs. Look at the sawtooth generator in Figure 3. The 4516 binary counter has BCD outputs (1, 2, 4, 8) that represent values from 0 to 16 in increments of 1. Let's set the current of the 1 output (Q0) to 40 μ A by placing a 130K resistor on pin Q0 to ground. This means that every time Q0 goes high, 40 μ A will flow through the resistor.

Now let's set the current of output 2 (Q1) to 80 μA – twice as much current as Q0. When Q0 is on and Q1 is off, 40 μA will flow. When Q0 is off and Q1 is on, 80 μA will flow. But when both Q0 and Q1 are on, 120 μA will flow – three times the amount of current through Q0 alone. Does that sound like the number 3?

By setting Q2 and Q3 to equal 160 μ A and 320 μ A, respectively, we can represent all the values from 0 to 16 using currents. These currents are summed at the node of a non-inverting op-amp and output as a voltage. Notice that again the sawtooth waveform isn't exactly a linear ramp, but a staircase of small individual voltage steps, as shown in Figure 1d. You can increase the resolution and remove the coarseness of the waveform by increasing the number of steps from four bits to five bits using a 4518 (Figure 1e). The greater the number of binary digits, the better the resolution of the sawtooth waveform.

The input frequency (LMC662 oscillator) determines the frequency



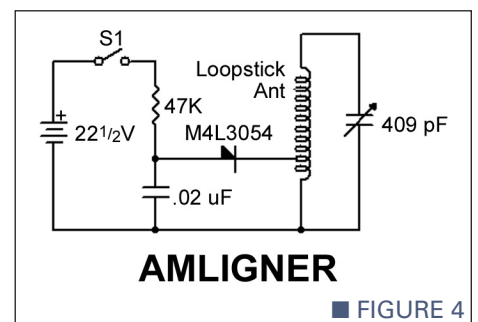
of the sawtooth waveform using the formula $f = 1/2^n$ where n is the number of weighed outputs.

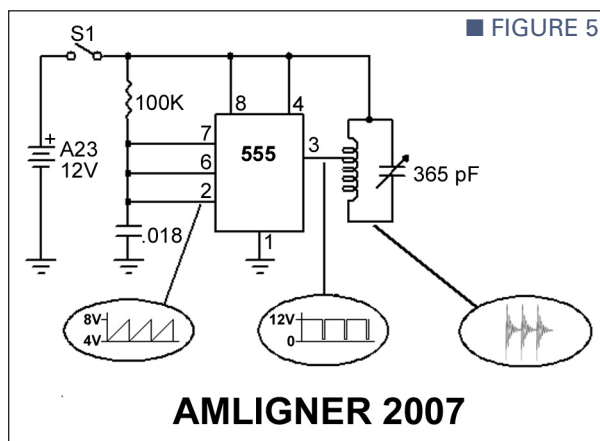
AM FREQUENCY GENERATOR

Q In the 1968 winter edition of the *Popular Electronics Experimenter's Handbook*, Don Lancaster published a simple signal generator project called the AMLIGNER, that used nothing more than a diode, a resistor, a coil, and two capacitors (see Figure 4). The diode was a Motorola M4L3054 four-layer device that is no longer available. Is there any substitute for the M4L3054? If not, what is your recommendation?

— **Dennis L. Farkas**
Ocala, FL

A While there is a four-layer diode equivalent of the M4L3054, I doubt it will fit comfortably into the original design. Aptly named a diac, this family of breakover diodes are made to trigger triacs in phase-controller circuits. Unfortunately, they have a characteristic breakover voltage range of 27 to 70 volts — far in excess of the 12 volt design voltage.





What is my recommendation? To use a 555 timer configured as a relaxation oscillator — a.k.a., a sawtooth oscillator. Like a breakover diode, the 555 lets a timing capacitor charge to a predetermined voltage, at which time it discharges the capacitor and generates an output pulse. And like the breakover diode, it needs only two external parts — a timing resistor and a timing capacitor — to accomplish this. The 555 has the added benefit that the input trigger is isolated from the output pulse, which means the impossible-to-find 22 1/2 volt battery can be replaced with a much smaller A23 (wireless doorbell) 12 volt alkaline battery. The new AMLIGNER is shown in Figure 5.

Because the original design is 40 years old and built with parts of its day, a few words about construction are in order. The tuning coil is a loopstick antenna salvaged from an AM transistor radio. They are easy to identify; just look for a coil wrapped around a three-inch (or so) ferrite rod.

tance of the different loopsticks changes. For example, the loopstick antenna sold by Scitoys requires a 160 pF tuning cap which — not coincidentally — happens to be the only variable cap they sell. Other than that, feel free to express yourself with your rendition of the new AMLIGNER 2007.

**[www.angelfire.com/electronic2/
index1/index.html](http://www.angelfire.com/electronic2/index1/index.html)**

www.scitoyscatalog.com

www.hobbytron.com

TROLLEY TRICKS

Q I use a Miniatronics RU1-1 point-to-point automatic reversing unit on my model train layout to control a trolley running up and down Main Street. Problem is, when the trolley gets to each end of the line it reverses instantly and takes off in the opposite direction. Can you suggest a way to

kill power to the tracks for a few seconds each time the track voltage is reversed?

— Don Hicke
San Diego, CA

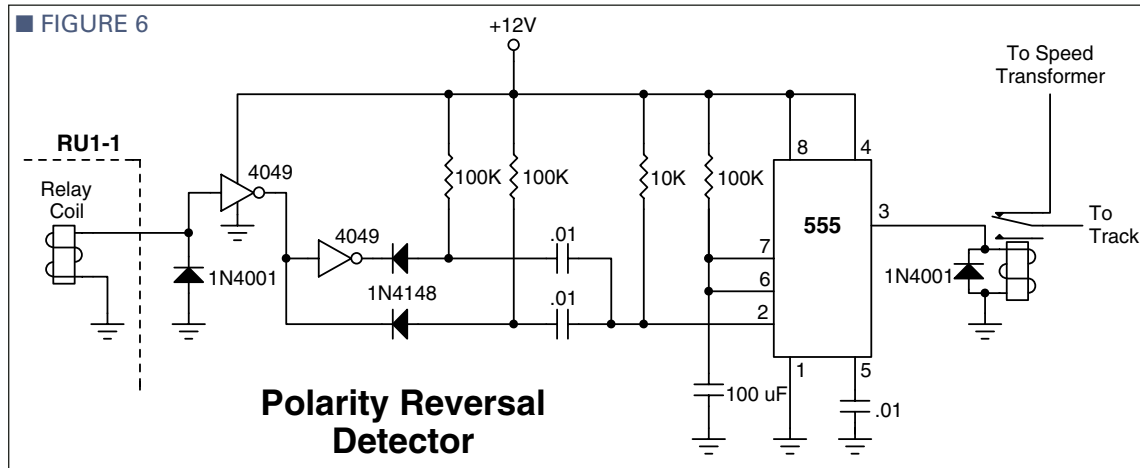
A The time delay is the easy part. The hard part is triggering the timer from a reversing DC voltage. After considering the alternatives, I decided to monitor the voltage across the RU1-1 reversing relay rather than the voltage across the trolley track itself. For one, the relay voltage is either on or off, and second, it's a constant 12 volts as opposed to a variable voltage that the speed controller places on the RR tracks. That done, I now needed to translate the relay voltage (or lack of) into a negative-going pulse to trigger the 555 timer. This I did using a pair of inverting logic gates.

When the gates are cascaded, a negative transition occurs alternately at the outputs of the inverters each time the relay is energized and de-energized. These outputs are then summed and fed to the time-delay's input trigger (pin 2). The result is the circuit shown in Figure 6.

The 1N4148 diodes, 100K pull-up resistors, and .01 μF caps are required to prevent the outputs from interacting with each other. Now each time the relay changes state – reversing the polarity across the tracks – the 555 activates the time delay relay, which cuts power to the tracks for the prescribed time. This is about 12 seconds for the values shown; increasing or decreasing the value of the 100 μF cap changes the delay time accordingly.

JOYSTICK SORROWS

Q A while back, I modified an arcade-quality digital joystick to emulate an analog stick for use with a MAME (Multiple Arcade



Machine Emulator). I used resistors and SPDT microswitches using info I found on the Internet to generate the appropriate resistance. This worked fine on the gameport of my old computer, but my new Dell, running Windows XP, only has USB ports and doesn't recognize the joystick. What is the easiest solution to this problem?

— Walter J. Maslowski

A Your analog joystick won't work because it has an analog interface and the USB port is a high speed serial interface. However, you have three solutions. The first is to replace your modified joystick with a USB joystick. They come in a wide range of models and prices, ranging anywhere from \$15 to \$50, depending on features. But I'll bet you're hooked on your analog joystick, or you wouldn't be writing. In this case, you can use a game port to USB adapter, like the RM-203 from Custom Sensors (www.usb-port.com/rm203.html). About \$30. If you have an empty PCI slot in your new PC, you can plug in a game port/MIDI adapter, which accepts your analog joystick. Just make sure to install the Windows XP software driver that comes with the board. Prices start at around \$20.

IN SEARCH OF VSS

Q When installing GPS units, I frequently need to tap into the VSS (Vehicle Speed Sensor) wire on vehicles. Most of the time it is very easy; the ECM (Electronics Control Module) on most vehicles is where you find it. But sometimes it becomes a laborious chore, taking hours to locate. On the newest Chrysler vehicles, for example, the VSS wire color changes from model to model, and some models use analog rather than digital signals. If I had a handheld device that could identify the VSS lead, life would be so much simpler.

— Mike Ventrella

A Let me first tell our readers that the reason for the GPS unit tapping into the VSS is to keep track of vehicle

movement when the satellite signals are blocked by tall buildings, trees, and tunnels. A vehicle speed sensor typically consists of a toothed ferrous metal gear, a sense coil, and a bias magnet (Figure 7). As the gear rotates, the magnetic field between the gear and the bias magnet changes because of changing distances between the magnetic material and the magnet. This induces a voltage into the sense coil that is converted into a square wave and distributed throughout the vehicle. This signal has an output voltage of five to seven volts and a frequency of 133 Hz at 60 MPH (based on 8,000 pulses per mile). When tracing the vehicle sense wire, one of the rear wheels is typically rotated by hand at 2 MPH, which results in a frequency of 4.4 Hz.

The circuit in Figure 8 is a monostable multivibrator that triggers on the positive-going edge of the square wave, causing the LED to light. A small coupling capacitor (0.01 μ F) prevents DC voltage from triggering the pulse-stretching, one-shot circuit, thus guaranteeing that only fast-rising AC signals (like the VSS square wave) will be detected — not low-voltage signal or +12 volt power lines. At 4.4 Hz, it's normal for the LED to flash about once per second, further enhancing the "got it!" effect. I wasn't able to run down the Chrysler analog VSS signal you speak about, but if you happen to run across one, it's

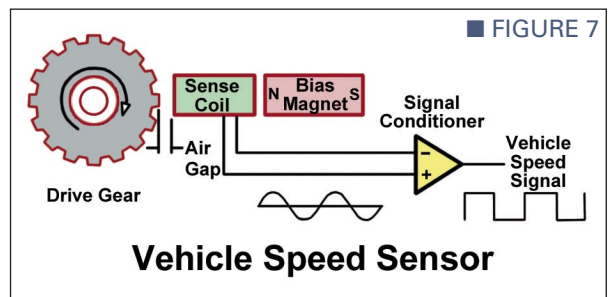
easy enough to convert it to a digital signal using a Schmitt gate, like the 40106.

CONNECTING MIDI

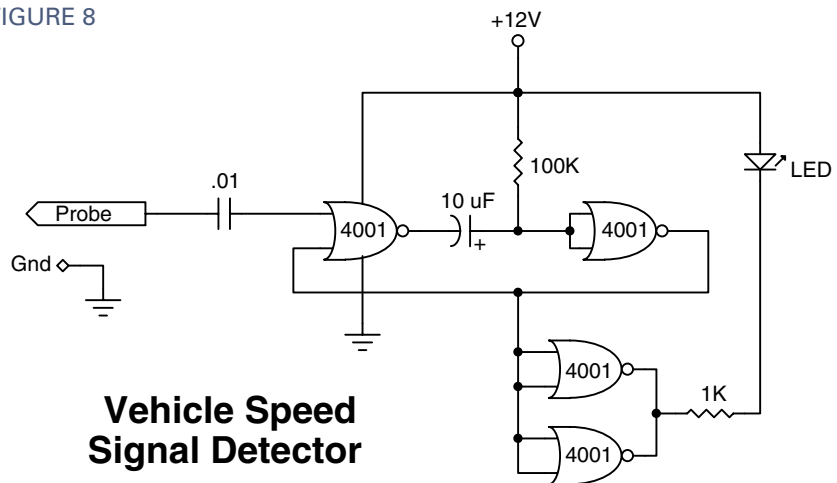
Q I am a 73-year-old who, after many years, has finally found time to attempt to enter the world of electronic music by way of keyboards — the magic(?) of MIDI. I have read a number of books on the subject, but still have trouble matching up channel outputs to sound module inputs, so here are my questions. Is there any way to insert something in line that will provide a readout of the particular channel being transmitted to a selected sound module in order to match them? Is there any method that allows me to switch from one sound module to another quickly while playing a keyboard with MIDI output?

— W.A. Lee

A You can monitor the activity on a MIDI line by simply placing an LED across the data wires, as shown in Figure 9. Notice that the LED/resistor



■ FIGURE 8



indicator can be inserted without cutting any wires — a plus for those of us who have paid a premium for gold-plated connectors. Flashing of the LED is normal as the MIDI port spits out 1s and 0s. As for switching between sound modules, this can be done using a switch box. Look for them on eBay under MIDI switch boxes. If you're up to building it yourself, gather together four five-pin DIN sockets, a three-position rotary switch, three resistors, and three LEDs, and assemble them as shown in Figure 10. While my example is limited to three MIDI devices, you are limited only by

the number of DIN connectors you can fit into the enclosure.

PHONE MESSAGE WAITING

Q I want to add an audio indicator to message waiting on our PBX. Currently, we have a neon lamp that flashes about once per second when we have a message waiting. (Our lamp is a module that plugs into the RJ45 phone jack.) What I would like to do is add an audio device (buzzer or speaker) that would emit a tone/sound at the same rate. Volume would be about the same as a microwave beeper and might include a pot to adjust it. I don't want to load the line down and would probably use a nine-volt battery. Do you have something quick, cheap, and easy?

— Kelly Hoffman
The University of Texas

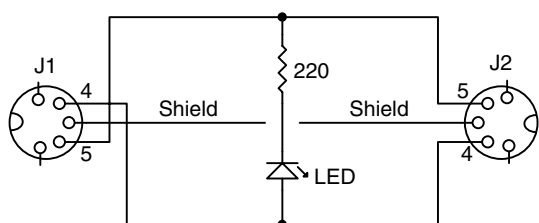
A It sounds to me like your phone service uses DC voltage neon technology for message waiting. There are three formats used for message waiting in current use. Neon technology accounts for about 50% of the phone systems that support message waiting lights. What the exchange does is place a 90 to 140 volt DC voltage on the line when a waiting message is pending. Because it is DC rather than AC, it won't activate the ringer. To verify my suspicions, test the phone line using a DC voltmeter on the 150 volt range. With the phone on-hook, the voltage across the Tip and Ring wires (red/green or yellow/black) should read about 50 volts at "rest." If you have a message, you will measure a constant or "flashing" DC voltage of 90 to 140 volts.

The best way to approach this project is with an optoisolator. This can be done using an optocoupler IC like the 4N33, or by making a DIY neon lamp/phototransistor combination (Figure 11). The latter has the advantage of being unpolarized — that is, you can connect it to either phone wire and the lamp will still light. The LED-controlled 4N33, on the other hand, won't work if the wires are reversed. If you opt for the neon lamp combination, couple the two together using a length of black shrink tubing. The tubing will hold the optical parts in alignment and keep out ambient room light. The phototransistor acts like an on/off switch. When the LED or neon lamp lights, the transistor conducts and applies voltage to the oscillator.

While the oscillator can be any audio device (such as an annoying buzzer or screaming piezo device), I thought you might like a pleasant bird sound. The "bird" generator is a modified Hartley oscillator that produces a chirping sound as C1 charges and discharges through the 2N2222 base-emitter junction. Feel free to experiment with different capacitance values to achieve other effects.

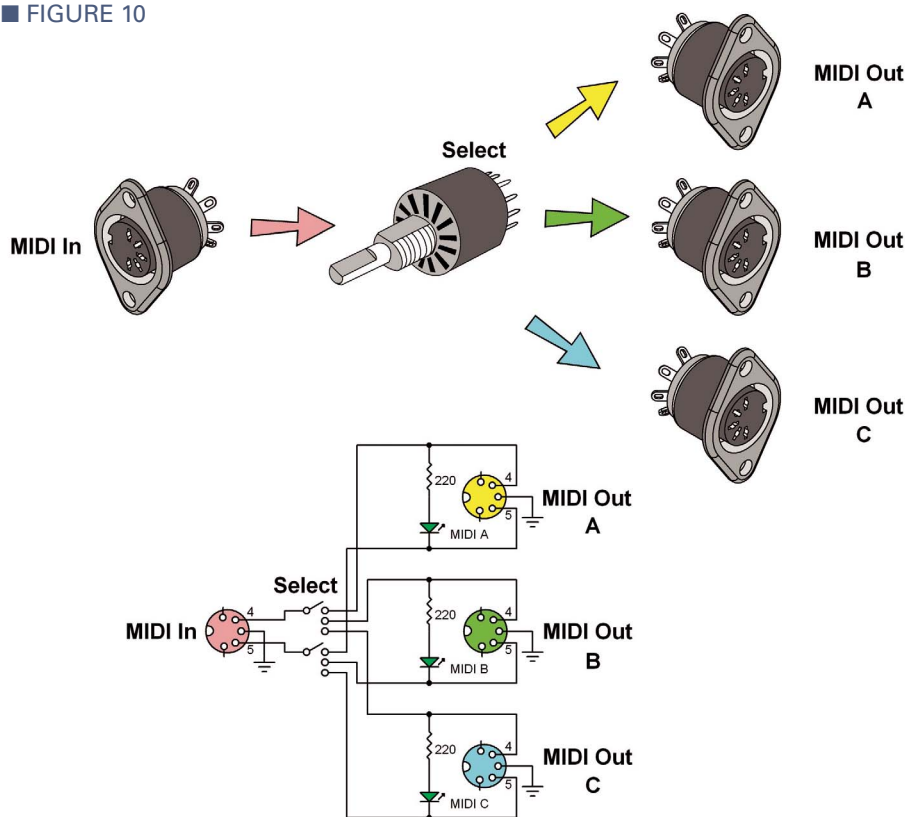
The audio transformer can be salvaged from an AM transistor radio (as can the speaker) or you can buy one from RadioShack (273-1380). The optional 47 ohm resistor is used to lower the speaker volume; alternative-

■ FIGURE 9



MIDI Transmit Indicator

■ FIGURE 10



MIDI Switch Box

MAILBAG

Dear TJ,

On your December '06 answer about IEEE-488 and USB, I too have many older instruments with an IEEE-488 (GPIB) port. Over the years, I have found several inexpensive ways to interface them to my PC. The cheapest way is to pick up surplus GPIB to RS-232 interface boxes made by National Instruments, IoTech, and the like. Since this is by now old-fashion technology, they can be found on eBay

for just tens of dollars. Look for model numbers such as GPIB-232CV-A, 232CT-A, IoTech's Serial, and Micro 488A. There is also a dirt cheap GPIB-to-USB converter on the market made by Prologix (www.prologix.biz). It's sold by SparkFun Electronics (www.sparkfun.com) for \$125, software included.

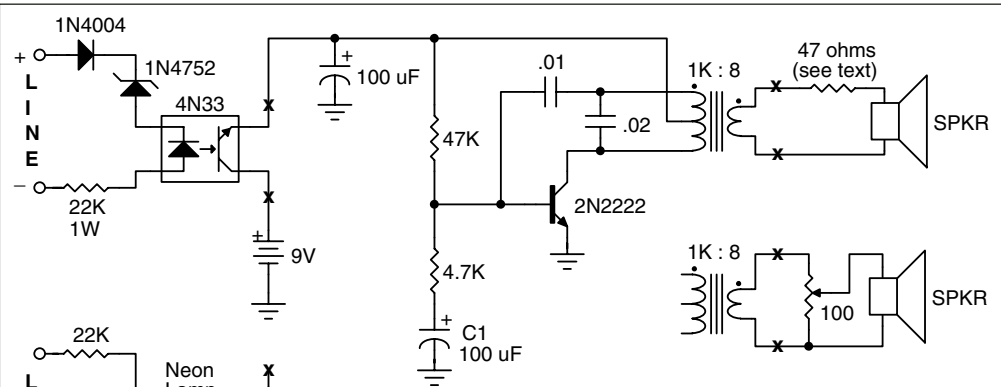
— TVB

www.LeapSecond.com

ly, a 100 ohm pot can be used instead to make a continuously variable volume control.

PHONE XMTR KEY

Q I would like a circuit that would key the mic on my transmitter when my home phone rings. I had originally thought about using an NE51 neon bulb with a photocell and a small relay, but I can't find an NE51 in my city. Do you have a better

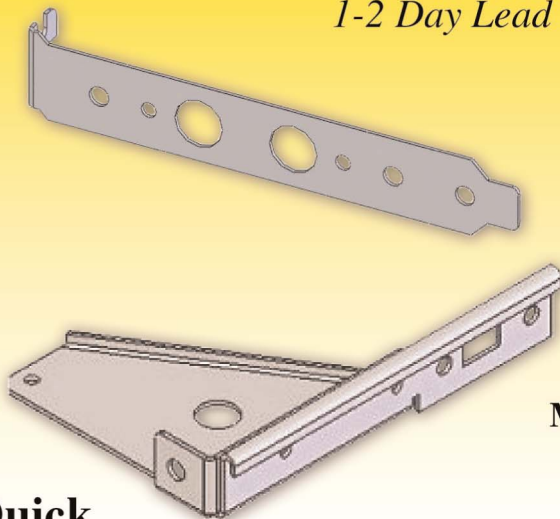


Light-To-Audio "Bird Chirp"

■ FIGURE 11

Metal Fabrication

1-2 Day Lead Times Available



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*Precision Laser, Waterjet, Plasma, Machining,
Forming, and Welding Capabilities*

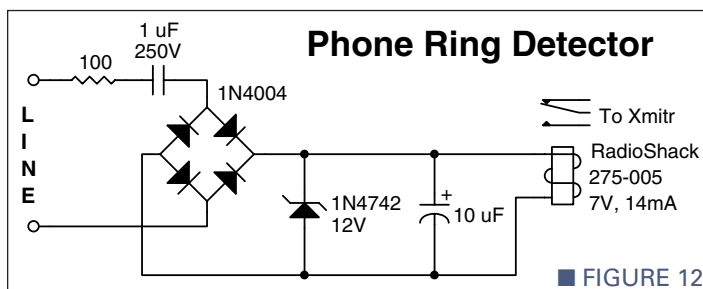
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circuit that wouldn't affect the phone line?
— Ray Escue
K4RDK


A This is one of those cases where, thankfully, you don't need optical line isolation. A coupling capacitor is all the isolation you need, plus the phone company provides all the power needed to drive a sensitive relay directly. No external battery needed! In most neigh-

borhoods, expect to find 100 volts at 20 Hz to 25 Hz. The circuit consists of an input cap, a bridge rectifier (made of four 1N4004 diodes), a voltage-limiting Zener diode, a filter cap, and a RadioShack relay (Figure 12). In fact,



with the exception of the 1 μ F cap, you can get all the parts from RadioShack. The 1 μ F cap is often found in small motors or ceiling fan speed controllers. Check your local appliance repair shop or do your shopping at one of the mail-order jobbers, like Jameco.

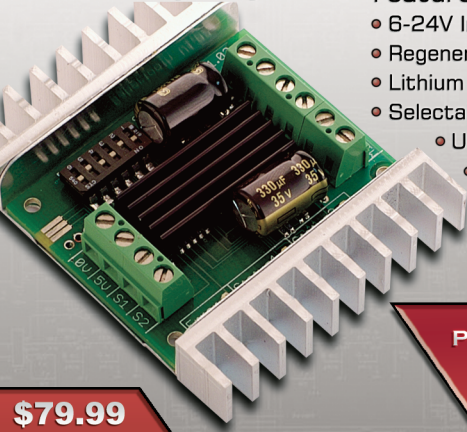
The ringer signal from the phone company's central office is a 20 to 60 Hz sine wave of 90 VAC to 150 VAC. The capacitive reactance of the 1 μ F input capacitor is about 6K to 8K, depending on the ringer frequency. This limits the ringer current to 14 mA, more or less — well within the pull-in range of the relay. Don't be concerned that the input voltage is 100 volts plus and that the relay is a mere seven volts. Relays are current operated devices and by limiting the current with the input cap, the relay coil will seek its correct operating voltage. But to be on the safe side, a 100 ohm input resistor and a 12 volt Zener diode protects the relay from surges and unexpected voltage spikes. **NV**



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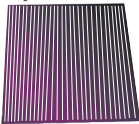
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G16131 \$28.95 ea.



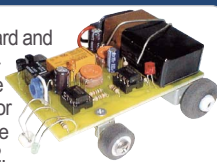
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Offer Expires 02/28/07

Super Power 12VDC Gear Motor

Sealed case gear motor was made for automotive applications. Motor operates on 12VDC and features 0.52" Dia. x 0.5" L shaft with 8 spines (or ridges). The shaft rotates at approximately 5RPM and has very high torque. Overall size including mounting ears about 4.2" x 3.2" x 1.1" Thick (without shaft). Part # PP-GF30 made by TRW. Has built in 2 pin male connector, however we do not have the matching female connector.

G16034 \$7.95 ea.



Bertsch Micro Motor

Small odd shaped motor by Bertsch has a unique armature (see picture for the three coil armature). It is about 0.93" L x 0.67" W x 0.39" D. It has a 1mm diameter x 2mm long shaft and two solder eyelets for connection. Operates on 3VDC up to 9VDC. Sorry, no other specs available.

G16260 \$3.49 ea.



Amazing Wire Glue

Brand new product is an electrically conductive glue. Make electrical connections quickly without heat or solder. Attach wires to glass solar panels, batteries, etc. using this amazing product. Highly conductive non-toxic no lead product is great for low voltage electrical connections. Just apply and allow to cure overnight. You'll find hundreds of uses for this amazing product. Brand new in blister pack jar containing 0.3FL oz.

G16133 \$3.95 ea.



T6 Torx Screwdriver

Small screwdriver for the T6 Torx screws is very handy to have around. We keep several of these in our toolsets here as we frequently run into T6 Torx screws on electronic assemblies. This screwdriver is lightweight and is good for overall use. We got tired of buying T6 Torx screwdrivers at up to \$10 each from the local hardware store and decided to start carrying this popular size ourselves. New in manufacturer's bag.

G16146 \$0.99 ea.



Handy 6 in 1 Screwdriver/Level/Flashlight

Handy 6 in 1 tool fits in your pocket.

You get two double sided quality tip bits (two different sized straight blades and two different sided phillips bits). It also has a hand white LED flashlight on screwdriver end to light up the screw you wish to remove or install. Finally it has a built in "bubble" level on the handle. Compact size, only 5.5" L x 1" W. Brand new in retail package. Black and silver color. Ready to use (batteries installed).

G16256 \$7.95 ea.



Rubber Grip 14 White LED Flashlight

This is our best compact 14 LED brilliant white flashlight. Comes complete with three "AAA" batteries. All metal body with rubber/non-slip grip. This has a pushbutton on/off switch on the end and a carrying strap. The beam on this is very bright! New in sealed retail package.

G16244 \$8.95 ea.



200V 1.5Amp WO26 Miniature Bridge

Type WO26 bridge rectifier is only about 0.36" Dia. x 0.17" Tall. Has four leads trimmed to about 0.18" long for PCB mounting. Special pricing!

G16255 4/\$0.99



Universal Tilt Adjustment Platform Assembly

Made for adjusting a mirror in an automobile this assembly consists of two internal motors with gears. By applying different polarity to each of the motors the motors can push/pull the platform. Overall size of the platform is 4.3" sq. x about 2" H. Platform can also be adjusted manually without damage. Operates from 12VDC up to 15VDC. Has female socket pins on motors for wire connections (2 on each motor that allows you to insert any solid 22 gauge wire for connections). Made in the USA by EATON.

G16067 \$6.49



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Absolutely our brightest red LED. This outputs an incredible 10,000 MCD when 2.7VDC is applied. Requires about 40mA. Crystal clear 5mm (T 1 3/4) lens. Color wavelength 640nm. Viewing angle 20°. By Sunled.

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Solid Tungsten Carbide PC Board Drill Bit Assortment

Consists of 10 different solid tungsten carbide drill bits made for PC board hole drilling. These came from a PC board manufacturer that closed and may have been resharpened or used drill bits. Each bit has a small collar on it and most have the size marked on it (some sizes may be metric). Bits range from big to 80 (very tiny). All shanks are standard 1/8". These will drill thousands of holes in PC boards, however you should use a drill press as flexing these tiny bits will break them! This is our best assortment- We find these bits very useful when making PC boards here at the Goldmine.

G15421 \$12.00



Optex F-51167NCU-FW-AA Color LCD Display w/ CFL Backlight

New very high quality Optex F-51167NCU-FW-AA color LCD display. Features 320 x 240 dots, a viewing area of 122.0mm(W) x 92.0mm(H), 8 - bit parallel data transfer and an overall size of 167.1mm(W) x 109.0mm(H) x 8.0mm(D). LCD supply voltage 5VDC. CFL voltage requirement (starting voltage) = 700Vrms - operating voltage = 430Vrms. Brand new worth over \$100! See link on our website for full spec sheet.

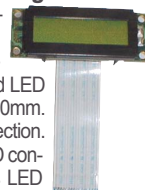
G16239 \$21.95 ea.



Hantronix HDM16216L-S 16 Character 2 Line LCD Display with Backlight

High quality miniature 2 line 16 characters per line display features an overall size of 53mm x 20mm. Standard 5 x 7 dot display with cursor and LED backlight. Viewing area is 36mm x 10mm. Has 16 pin flat ribbon cable for connection. This display module has a built in LCD controller IC, and driver IC. Display has LED backlight. Complete specs and hookup information are available on the internet. The part number that is printed on ribbon cable is HDM16216L-S-LC1P. Brand new display and is worth over \$9 each!

G16081 \$3.95 ea.

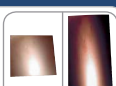


Scissor Cut SS Copper Clad

Simple to use - just cut this copper clad to your desired size using a pair of scissors. Features copper on one side for easy etching and a thickness of only 0.016" which makes it somewhat flexible and easy to cut to size. Great for making all types of electronic projects. Has peel off protective backing on one side.

G15697 5.5" x 6" \$0.99 ea.

G15698 5.5" x 12" \$1.75 ea.



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Full factory tube of thirty 16 pin machine pin low profile sockets. Brand new. Blowout price!

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A63/LR41 Tiny Alkaline Batteries

These power up heaving aids, tiny calculators, body jewelry lights, etc. Size about 7.9mm x 3.6mm. Rated 1.5V each. Package of three. New!

G16258 \$0.99/Pkg of 3



Solid Carbide Spiral Upcut Router Bit

Solid carbide 1/8" Dia. shaft spiral upcut router bit has a cutter diameter of 2.0mm and a 1/4" L cutting length. These are razor sharp and have been professionally repointed.

G15796 \$1.00 ea.





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USB MOTION DETECTION SYSTEM

Kadtronix introduces the USB Motion Detector (UMD) system. Costing as low as \$91 in single-unit quantity, the system is comprised of the following elements: USB motion detector, USB wiring interface, and Windows software.

This product was developed for applications needing to perform motion-triggered actions under PC control. Combined with a Windows PC or laptop, the UMD becomes the basis of a smart motion-activated system. Automatically send email, run applications, play .wav sounds, set digital outputs, play multimedia presentations, and more.

Utilizing existing Windows drivers, no custom drivers are needed. Included with the UMD is the USB Digital I/O Commander "Digio" software. This software allows you to define and customize system parameters for your specific application. Using Digio, configure the system for any of these applications and more:

- Security systems
- Industrial control
- Robotics
- Kiosks
- PowerPoint presentations
- Research

Digio can be configured for use in motion-activated slideshows and videos, making it well-suited for use in computer-based kiosks. Run motion-activated multimedia presentations in shopping malls, airports, convenience stores, etc.

The USB interface features 16 configurable I/O signals and a six-foot



length of cable with attached USB connector (may be used with a USB extender for distances up to 100 feet or more).

This do-it-yourself system provides a low-cost option for those with knowledge of low-voltage wiring and assembly. (Motion detector and AC power adapter sold separately.) Also available is a complete turn-key system including motion detector, USB interface, and Digio software, all pre-wired and ready for installation.

For more information, contact:
Delahoussaye Consulting
Tel: 321-757-9280
Email: info@kadtronix.com
Web: www.kadtronix.com

ACCELERATION DATA LOGGER

Onset Computer Corporation — a leading supplier of battery-powered data loggers — has unveiled the HOBOPendant G Logger — an easy-to-use data logger for measuring and recording tilt, orientation, activity, and motion.

Roughly half the size of an iPod® Shuffle, the new HOBOPendant G makes it easy to record data in any

environment — in the home, outside, and even underwater.

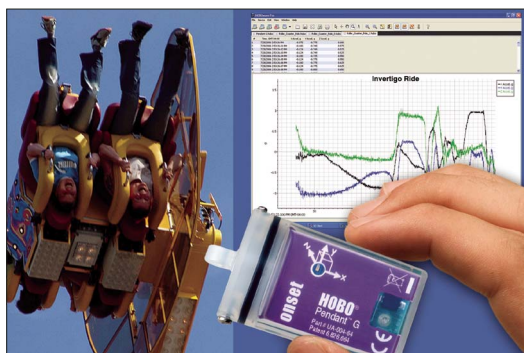
Gadget lovers of all types — from electronics hobbyists to students to amateur scientists — will use the HOBOPendant G logger in a broad range of activities, from recording G forces on rollercoasters to measuring activity patterns of people and/or pets.

Once data has been collected, users can display the data in colorful, easily recognizable graphs on a PC or Mac, and print out the graphs to share with others.

The HOBOPendant G incorporates a state-of-the-art, omni-directional accelerometer and onboard memory capable of storing 64,000 measurements. It also provides a convenient, direct-USB interface for linking to a computer, and works with HOBOWare® Lite, a user-friendly graphing and analysis software package.

The HOBOPendant G Data Logger Kit — which includes the data logger, HOBOWare Lite software, mounting bracket, and USB optic base station — is available now. Check the website for current pricing.

For more information, contact:
Onset Computer Corporation
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NEW LINE OF DYNAMIC BRAKING RESISTORS

Milwaukee Resistor Corporation — now in their 62nd year of business — just introduced a new line of Dynamic Braking Resistors that

are used with both AC Variable Frequency Drives and DC Drive applications. This new line of dynamic braking resistors are rated between 300 watts and 6,000 watts and are ready for shipment in as little as 24 hours. This new line offers resistors mounted in NEMA type 1 enclosures and are pre-wired for easy installation both at the OEM's factory and at an industrial job-site.



The enclosure is constructed from aluminum and includes two endplates and a screened cover. Milwaukee Resistor Corporation stocks numerous ohmic values of 300 watt and 1,500 watt resistors which provides the ability to quickly ship dynamic braking resistors up to 6,000 watts. Series/parallel wiring combinations of these stock values are utilized to create numerous other resistance values and braking packages up to 19.2 kw are also available.

When a load is being decelerated, the motor acts as a generator, converting the kinetic energy of the load to electrical energy. The dynamic braking circuit converts this electrical energy into another form (heat) through the use of dynamic braking resistors to slow the load. The resistors are sized based on braking torque (ohms) and heat dissipation (watts) as recommended by the manufacturer of the drive and application.

For more information, contact:
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Milwaukee, WI 53224

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Web: www.milwaukee-resistor.com

CH MULTI FUNCTION PANEL

CH Products and Ergodex announce the CH Multi Function Panel (MFP). The revolutionary MFP enables flight simmers to design their own cockpits, either duplicating any existing aircraft from a Cessna 172 to

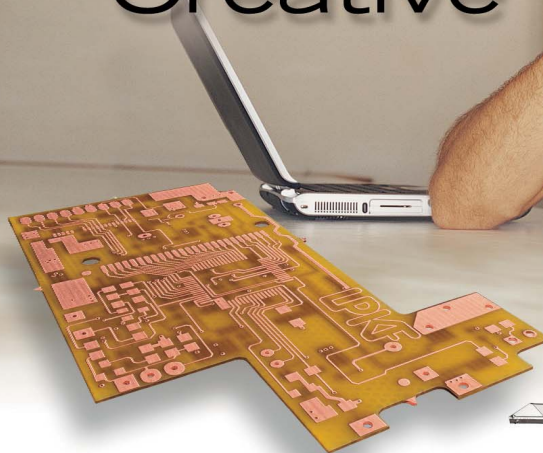
F-16 Fighting Falcon to a Boeing 777, or designing their own novel cockpit. Each MFP comes with 25 keys which can be positioned, removed, and re-positioned to any location on the panel's "active surface," making each MFP completely customizable. Each of the 25 keys is movable, programmable, wireless, and has no batteries. By using MFPs to emulate avionics panels, communica-



tions panels, or GPS panels, flight simmers get added realism in their desktop or home-built cockpits. Through the placement and programming of keys on the MFP, any avionics panel can be emulated.

The CH Control Manager™, optimized for flight simulation and other entertainment software, is combined in the MFP with Ergodex' technology, allowing up to 16 panels

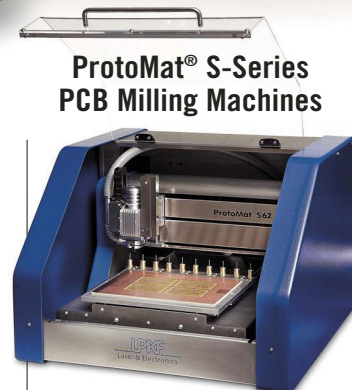
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to be used on a single PC. The MFP also includes a removable clear tray that allows users to create custom key templates to be placed underneath the tray, aiding in the identification of key placement and adding realism. Sample templates – such as the one shown in the photo – will be available at no charge on the CH website, as well as the CH Hangar website.

The MFP is designed for any Windows application, including – but not limited to – PC Gaming and Flight

Simulation. The MFP has the same functionality as a keyboard, with some major advantages. Each key can be removed and re-positioned wherever the user wants on the MFP tray. Each key is held in place with a re-usable, inexhaustible adhesive, sometimes called “Molecular Velcro,” which allows re-positioning the keys over and over again, without losing any “stickiness.” The MFP can be seen on the CH Hangar website and ordered at www.chproducts.com/shop/usb.html#23.

With CH’s Control Manager – which supports Windows 98, ME, 2K, XP, and XP 64 bit – a flight sim enthusiast can add up to 16 CH controllers, including multiple MFPs. Software such as Flight Sim, Combat Sim, and so on, sees the controllers as one device. With Control Manager, games which are limited to supporting only one controller can be used with many controllers.

“Adding the MFP to our joysticks, yokes, throttles, and the rest of our product line gives our customers the opportunity to build complete and realistic cockpit environments on a desktop for a minimal price,” stated Debby McDowell, Director of Marketing for CH Products. “This is a real breakthrough for PC gaming and will take our customers to a new level of added realism.”

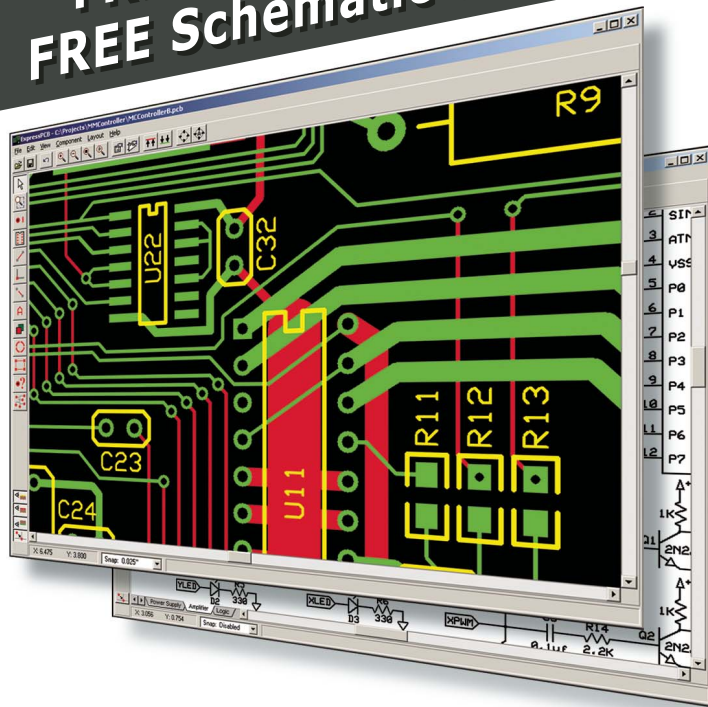
“This product is our first thrust in OEM channel for bringing Ergodex technology to customers in new markets. Working with CH Products to bring the Ergodex Engine to flight simmers and other gaming enthusiasts is an exciting new avenue for our technology” said Scott Rix, CTO of Ergodex. “New features and new implementations of the Ergodex technology are coming not only in products from Ergodex, but also in OEM product lines, such as CH’s MFP, and in the form of licensed technology in new instrumentation both within and outside the computer industry.”

The MFP allows you to program each key in any way you want, depending on the game. Each key can perform as any combination of the following: keystrokes, joystick buttons, mouse buttons, joystick axis, and mouse axis. Additional trays and keys may be purchased so that the customer can set up one tray for one game, another tray for another game, a third tray for Windows applications (such as Photoshop or Word), and so on. The MFP includes one CH Panel, one clear key tray, one set of keys (keys 1-25), and CH Control Manager Software version 5.0.

For more information, contact:
CH Products or Ergodex
Web: www.chproducts.com or
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FREESCALE DESIGN CHALLENGE LOOKS FOR THE NEXT EIGHT-BIT KILLER APP

North American developers to vie for \$10,000 grand prize and chance to demonstrate winning app at the 2007 Freescale Technology Forum

Freescale Semiconductor is offering embedded engineers and engineering students in the United States, Canada, and Mexico the opportunity to free their imaginations and turn great design ideas into eight-bit innovations.

The Black Widow \$10,000 Design Challenge rewards the most inventive designs with cash prizes and high-profile recognition. Registration for the design challenge opened Jan. 15 and closes April 6, 2007.

Design Challenge Details

Contestants can register for the design challenge at www.freescale.com/blackwidow. Once registered, they will follow three steps and gain access to a wealth of design support. In step one, contestants will test their knowledge in a short question-and-answer session. In step two, they will participate in a short coding demonstration using Freescale's virtual lab on

the DEMO9S08QG8 board. In addition, they will have the opportunity to purchase Freescale's USBSYPDER08 development tool at a 50-percent discount. In step three, contestants will submit their application concepts.

All entries must be submitted online by April 6. Entries may be submitted by individuals or groups. Each submission will be reviewed by a panel of Freescale judges for creativity, design efficiency, technical complexity, total Freescale product quantity, usefulness, and overall application rating.

Freescale plans to announce the top 10 finalists on April 13. Each finalist will receive a \$1,000 (USD) award. The finalists will be invited to build prototypes of their designs and submit them to Freescale for final judging. The grand prize winner will receive \$10,000 and free admission to the Freescale Technology Forum (FTF) in Orlando, FL, June 25-28, 2007. The second and third prize winners will receive \$5,000 and \$2,000, respectively.

KUDOS CONTINUE AS CLUB PENGUIN MARKS ONE-YEAR ANNIVERSARY

Just one year after it launched, Club Penguin (www.clubpenguin.com)

continues to reach new milestones of success and garner kudos for the quality of its product and its work improving Internet safety for kids.

The popular website that allows children to play games and chat in one of the safest online environments to date was recently chosen by *Children's Technology Review* (CTR) to receive its coveted Editor's Choice Award.

CTR is an independent monthly survey that reviews children's technology products from professional educators' perspectives.

In a recent review of Club Penguin, CTR awarded the site 4.5 stars out of 5, saying, "The experience is social and easy to play, and it offers a variety of informal learning opportunities. As a language experience, the program gets children busily typing with others, and there are a variety of games that require logical thinking and strategy. All in all, this is a noteworthy service."

"It's gratifying to receive such a high rating from a publication that is a trusted source for unbiased and credible reviews of technology products aimed specifically at children," says Lane Merrifield of Club Penguin. "Our sole focus at Club Penguin is the safety and enjoyment of our young users and we really value the support of other organizations that display a similarly strong commitment to children and families."

Since Club Penguin launched its virtual world populated by colorful, animated penguins in October 2005, it has experienced a rapid growth in popularity and reputation.

In March 2006, Club Penguin made its debut on **Miniclip.com**, the world's largest website dedicated to playing online games. A month later, Club Penguin was the number one game on the site; a position it has consistently maintained ever since.

With concerns about online safety for children at an all-time high, Club Penguin has also garnered favorable reviews for its commitment to protecting its young users.

Thanks to a sophisticated filtering system and the presence of live moderators who monitor what's going on in the world and deal with any

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reports of misconduct, Club Penguin offers unprecedented peace of mind for parents. It also adheres to a strict privacy policy and includes no advertising.

"Although advertising certainly has its place in the world of adults, I don't think it belongs on a site dedicated to children," says Merrifield, a father of two. "I wouldn't let my child watch an hour of advertising on TV. So why would I on the web?"

Club Penguin recently partnered with NetSmartz Workshop, a leading educational safety resource that teaches children and teens how to stay safer on the Internet. The site was also selected by the Better Business Bureau's BBB OnLine program to receive its Kid's Privacy Seal of Approval, a respected designation currently held by less than a dozen other companies in the world. Club Penguin is designed for 8-14 year olds, but is open to children of all ages. Although the site is funded by subscriptions, you don't have to be a paying member to visit or play games.

SURVIVALTAG DESIGNED TO SAVE FIREFIGHTERS' LIVES

SurvivalTag, the latest in life-saving radio frequency identification (RFID) technology for firefighters, is in the final design phase. Embedded in uniforms, fire chiefs and commanders will be able to use the SurvivalTag System to track their emergency personnel squads in at-risk, on-scene situations pinpointing the wearer's location for possible rescue by other squad members if and when necessary.

Influenced by fire chiefs and commanders, RFID, LTD. is designing and developing a complete SurvivalTag System that not only monitors the locations of squads but also their heart rates, respiratory developments, and skin temperatures.

RFID, LTD. formulates, tests, and deploys vendor neutral Radio Frequency Identification solutions.

MICROCHIP'S GLOBAL SALES TEAM NAMED AS FINALIST

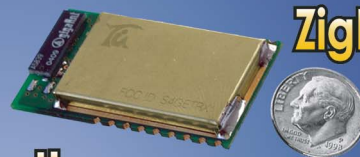
Microchip Technology, Inc., a leading provider of microcontroller and analog semiconductors, announced that Mitch Little, vice president of worldwide sales and applications, was honored with a Stevie® Award in the "Worldwide VP of Sales of the Year" category in The 2006 Selling Power Sales Excellence Awards. Additionally, Microchip's worldwide sales organization was named a finalist in the "Global Sales Team of the Year" category.

This prestigious award honored Mitch Little and the Microchip sales team for their significant achievements during the past year, including the effective addition of nearly 30% more sales and applications resources to the global team, at all levels. The elegant Stevie trophy was designed by R. S. Owens, the same company that makes the Oscar and the Emmy. **NV**

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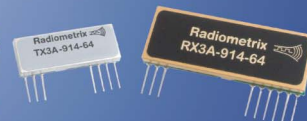
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■ LEVEL RATING SYSTEM

To find out the level of difficulty for each of these projects, turn to our ratings for the answers.

- Beginner Level
- Intermediate Level
- Advanced Level
- Professional Level

I have always been fascinated by the weather. I own several of those remote gauges; you know, the ones that sit on your desk and display the outside temperature and humidity. Some display rainfall, while others display barometric pressure. I even have a couple that display a neat little forecast of the upcoming weather. And then it occurred to me ...

Why not build my own weather station?

CONTROL YOUR WORLD

Home Automation: Catch the Wind



■ FIGURE 1

This is the first in a series of articles where I will take you into the world of building your own weather station and home automation system. I live in a rural environment where violent thunder storms seem to seek me out as if they are on a search and destroy mission. I have lost every single TV antenna I have placed on my roof. I have had to replace five ISDN routers. When a bad storm rolls through, I run around the house like a madman unplugging things and shouting "the rain," "the rain."

Anyway ... wouldn't it be cool to automatically detect the lightning and turn off or isolate various devices? This is exactly what we are going to do in future articles, as we build a home automation system using X10.

Let's take some time and look at a wind speed sensor, otherwise known as an anemometer. I will show you three types. It may look like we are starting in the middle, as many would have started with a temperature or humidity gauge first. I wanted to jump feet first into anemometers since they are one of the most expensive and most

complicated devices in the home weather station. The anemometer is also the coolest and most responsive environmental sensor. It can display real-time information several times a second.

I built four completely different weather stations while researching this series, and with each I found that starting with the anemometer seemed to make the assembly of the rest of the station proceed the smoothest.

While the basic construction of most anemometers is similar, there are three approaches you may take in adding one to your weather station:

- Building a homemade anemometer.
- Purchasing and building an anemometer kit.
- Purchasing a fully assembled anemometer.

All three approaches are very reasonable in cost. After I discuss the mechanical aspects of each device, I will provide some basic hookup and testing instructions.

Homemade Anemometer

One of the most difficult aspects of making an anemometer is the construction of the cup and hub assembly. If they are not perfectly balanced, the anemometer may not operate properly or even worse, fly apart at high speeds. A company called ForceField has solved this problem for us. They offer a molded plastic cup and hub assembly for around \$20.

As shown in Figure 2, the assembly has a very small pre-drilled hole in the center, so all we need to do is enlarge it to the correct size and it will always be dead center.

Our homemade anemometer will feature this assembly. We will build a small ball bearing mount to attach the assembly and a couple of magnets and a reed sensor. Don't panic; the reed sensor is nothing more than the small glass reed removed from a reed relay that you can purchase from your local RadioShack.

To interface this anemometer, we will use a small, 1-Wire board available from a company called Hobby Boards. You will be hearing more about Hobby Boards later in this article, as well as throughout the series.

The dual counter shown in Figure 3 is a very small board that measures about 3/4" x 1". It has a small battery that will allow the onboard DS2423 to retain its counts for years.

Schematic 1 shows the basic hookup for connecting a reed to the counter. The cool thing about the onboard DS2423 is that it has built-in denounce so you don't have to worry about any additionally circuitry. Notice that we are only using half of the counter so later we can connect some other sensor like a

rain gauge or another anemometer.

Features of the Homemade Anemometer

- This is the most sensitive anemometer out of the three. I ran several tests outside, and on very calm days this was the only anemometer turning. The cup assembly has the lowest mass so it takes much less air flow to get it going and it also tended to track the variations in winds much better than the others.

- This device is very resistant to water damage due to its simple design.

- Since you are building the unit, it will be very easy to repair or replace parts.

- This anemometer has the smallest footprint and weighs the least of all three, so the weather pole used can be quite small.

- It's not restricted to 1-Wire. You can use several interface options.

I ran tests up to 50 MPH with my car, so this anemometer should hold up nicely under most weather conditions. This anemometer uses the following formula:

$$\text{MPH} = \text{counts over 1.5 second time period} * .88$$



■ FIGURE 2

Take a counter reading, wait 1.5 seconds, then take another. Subtract the first from the second and multiply by .88.

Homemade Anemometer Assembly

Before you proceed, please read through all the instructions. You will need the following tools to complete this project:

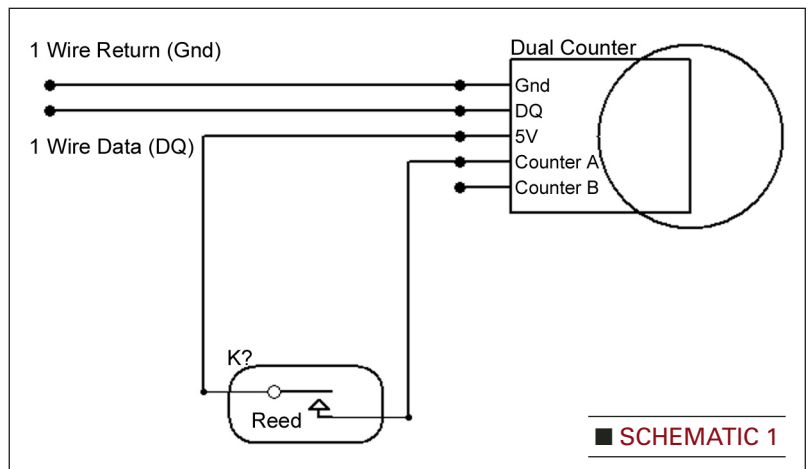
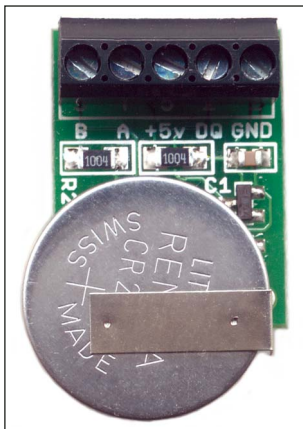
- *Drill* — This can be any kind of drill. You will also need 1/8" and 5/16" drill bits.

- *Pliers* — You will need these to tighten the lock nut.

- *Screwdriver* — You will need this to tighten the machine screw.

- *Soldering Iron* — This is needed for

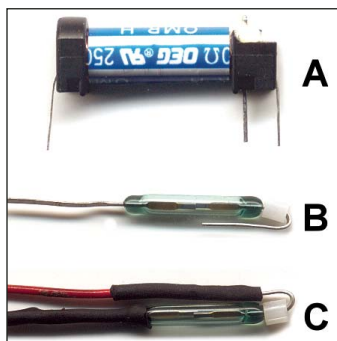
■ FIGURE 3



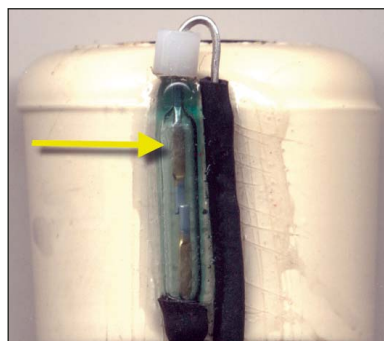
■ SCHEMATIC 1



■ FIGURE 4



■ FIGURE 5



■ FIGURE 6

bearing upside down over the bushing.

- Add the remaining 1/8" bushing and then the lock nut. Since this is a dry fit, you may want to use a standard #6 hex nut to ease disassembly.

At this point, you should be able to

connecting wires to the reed sensor.

- **6-32 Tap** — This is needed to tap a small piece of brass tubing. These can be purchased for a couple of dollars at your local home center.

- **Two-Part Epoxy** — Needed to attach a couple of the components.

- **PVC Glue** — Needed for connecting various PVC pipe sections permanently.

- **Hacksaw** — This is needed to cut the various lengths of PVC pipe.

Please note that you will most likely need all these tools for all three of the anemometers except for the #6-32 tap.

STEP 1: Prepare the anemometer hub.

Drill a 1/8" hole into the center of the anemometer hub. There is already a small hole that will act as a guide (Figure 2). Once you have the hole drilled, use a 6-32 tap to thread the hole. As an option, you can drill a slightly larger hole and forego the threading. Make sure you keep the drill straight as you proceed.

STEP 2: Prepare the PVC cap.

Drill a 5/16" hole into the center of a 1/2" PVC cap. I recommend you make the hole slightly off-center about 1/16" of an inch or so. This will give you a bit more clearance when mounting the reed. You should not be able to press-fit the 5/16" bearing into the hole. This is done by placing the cap upside down on top of the bearing and gently tapping the PVC cap. If the bearing does not have a tight fit, use some two-

part epoxy on the edges before inserting. Make sure you don't get epoxy on the center surface area of the bearing or it won't turn freely. The top of the bearing should be flush with the top of the PVC cap, as in Figure 4.

STEP 3: Tap a small bushing.

Take a piece of 5/32 brass tubing and using the 6-32 tap, add about half of the threads to the end of the rod. The best way to do this is to add a few drops of machine oil. Make sure you tap a single thread, then back it out to clear the material. Once you have 1/2" of the brass tubing tapped, cut it off. This will yield you a small 5/32 piece of threaded tubing.

STEP 4: Create more bushings.

Cut a 1/8" piece of 3/16 brass tubing and a 1/4" piece of brass tubing. Clean the edges so that they are free from burs. It is important that the cuts are straight or the anemometer will wobble.

STEP 5: Dry-fit the assembly.

- Place a #6 stainless steel washer onto a 1-1/4" #6 machine screw (6-32 is good), then insert the assembly through the top of the hole you drilled into the anemometer hub.

- Thread the threaded bushing onto the machine screw that is protruding inside the anemometer hub.

- Now place the 1/4" bushing over the threaded bushing.

- Insert the 1/2" PVC cap with the

rotate the cap freely while holding the hub in your hand. As you rotate the PVC cap, you will probably notice that it is not perfectly centered. Mark the point on the cap where it is the furthest from the inside of the anemometer hub, i.e., the area with the most clearance.

STEP 6: Attach the magnets.

Remove the PVC cap and bushings from the assembly. Leave the machine screw in place. About 3/8" down from the edge of the anemometer hub, attach one of the small Neodymium magnets with some two-part epoxy. Mix only a small amount of epoxy since you can only mount one magnet at a time. Do not get any epoxy on the protruding machine screw. Once the epoxy has hardened, place a second magnet on the opposite side of the hub in the same position. Use the protruding machine screw to help you line up the second magnet. Again, mix up some two-part epoxy and glue in place. It is important that the magnet is not more than 3/16" thick or there won't be enough clearance for the reed that we will install later.

STEP 7: Prepare the reed.

If you purchased a reed relay from RadioShack, you need to remove the glass sensor from the relay. This is a very simple process. Bend both of the contact leads so that they are in line with the relay. One of the contact leads will be protruding through an opening that is large enough for the glass element to pass through. Simply pull on this lead and the reed will separate from the relay. One end of the reed has

a small plastic spacer. Leave this in place and bend that lead as shown in Figure 5B. With a couple pieces of 1/16" heat shrink, solder two 24" lengths of wire to each lead as shown in Figure 5C.

STEP 8: Attach the reed to the PVC cap.

Attach the reed to the cap as shown in Figure 6. It is important that the magnet passes over the spot indicated by the arrow. You can always change the lengths of the 3/16" bushings after the reed is in place. There is a great deal of leeway for the placement as the Neodymium magnets are very powerful. You can use a small twisted wire to hold the reed in place while the epoxy dries.

That's it for the mechanical assembly of the homemade anemometer. At the end of this article, I will talk about the hookup and testing.

Anemometer Kit

For those of you who don't want to build an anemometer from the ground up, your next option is to purchase a complete kit. A company called Fascinating Electronics sells the perfect anemometer kit to get your home weather station started.

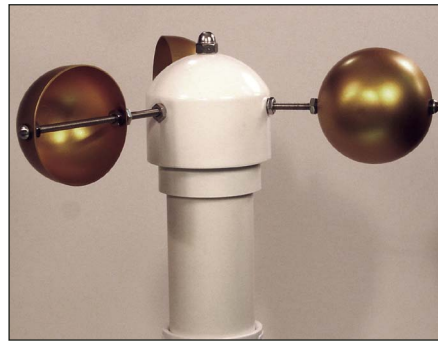
The kit costs \$49.90, and this is one nice kit. You get everything you need to build the anemometer. We will use the Hobby Boards counter board as before to interface to our PC. Of the three units, this is the most rugged anemometer. It features real aluminum cups and the design makes for a really water-tight system. Like our homemade anemometer, it comes with a reed that is triggered twice with each revolution. The hookup is identical as well: Simply connect the anemometer reed to the counter as shown in Schematic 1.

Features of the Complete Kit

- This device is very resistant to water



■ FIGURE 7



■ FIGURE 8

damage due to its simple design.

- Of the three, this is the most rugged design.
- Aluminum cups.
- This is the most professional looking device tested.
- It has a matching, very heavy duty wind vane that can be purchased.
- Not restricted to 1-Wire. You can use several interface options.
- 1-1/2" PVC mounting gives you many placement options.

The only downside I have found with this anemometer is that since the hub assembly has so much mass, it takes a bit more wind than the other two devices tested to get moving. Normally, this will not be a problem as we are talking about one MPH, and at those low speeds, it's a moot issue any way.

The assembly of this kit will take you one to two hours. The anemometer, once finished, mounts on 1-1/2" PVC pipe as shown in Figure 8.

Use a couple of 1-1/2" U-bolts to attach a 1' section of PVC pipe to your weather pole, then all you need to do is slip the anemometer on to the pipe as shown in Figure 9.

Fascinating Electronics sells a T mount for mounting the anemometer, as well as an electronic weather vane. This weather vane features a full 360 degree reading with no dead zones. We will be looking at this instrument in detail next month.

This anemometer uses the following formula:

$$\text{MPH} = \frac{\text{counts}}{\text{over 1.67 second time period} + 2}$$

Take a counter reading, wait 1.67 seconds, then take another. Subtract the first from the second and add 2. The result will be the MPH.

Complete Wind Instrument

A while back, Dallas offered a small weather instrument to demonstrate the use of their chips as sensors. This was a perfect solution for those wanting to build their own weather station. They no longer offer the device, but a company named AAG Electronica does. The unit that AAG offers is actually an improved version of the original.

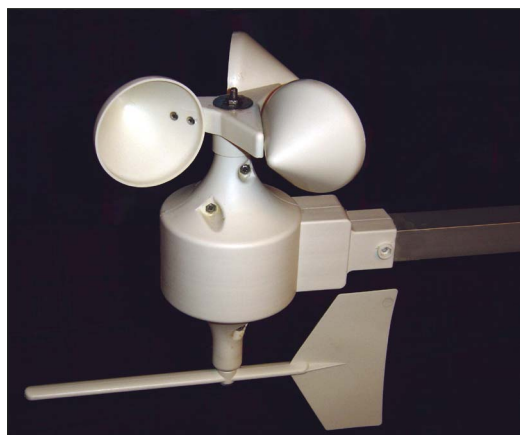
Hobby Boards is a US distributor of the AAG unit. I prefer to work with them because the owner Eric Vickery has been very responsive. Hobby Boards also offers several other 1-Wire sensors, many of which we will be looking at in the upcoming articles in this series.

Features of the AAG Instrument

- Very sensitive to wind speed and direction.
- Self-contained unit features three instruments: wind speed, wind



■ FIGURE 9



■ FIGURE 10



■ FIGURE 11

direction, and temperature.

- Simple 1-Wire interface. It is possible to install and use this device without soldering a single wire.

The AAG weather instrument comes partially assembled. You will need to open up the main housing in

order to install the wind direction vane. This will take you 15-30 minutes. You will also need to coat all of the external seams with some sort of sealant to keep water from entering the instrument. The PCB inside the housing is coated for protection but the RJ12 connectors are not.

I have had more than a few issues with water. Eventually, I used a gutter sealant and that seemed to solve all my water problems. Once assembled, the anemometer cups are located at the top and the wind vane on the bottom as shown in Figure 10.

To mount this instrument,

you will need to purchase a U-bolt. I use a 1-1/2" U-bolt. This size will work for just about any size mast up to 1-1/2" in diameter.

You will need to drill two holes in the aluminum mounting rod that comes with the AAG instrument as shown in Figure 10.

You should download the assembly instructions for this device. They are outdated and refer to the older V2.0 unit, but contain most of the information you will need for the mechanical assembly.

The instrument uses three Dallas 1-Wire chips used to collect weather data. A DS2423 is used to collect wind speed data. A DS2450 is used to calculate wind direction data with a resolution of 16 compass points. A DS18S20 is used for temperature measurements. The instrument can be made to operate off of 5V, but is set by default to use 1-Wire parasite power. In parasite power mode, you only need two wires connected to the unit to retrieve the data from any of the sensors. I will be going into more detail about the use of 1-Wire sensors, as well as other alternatives next month.

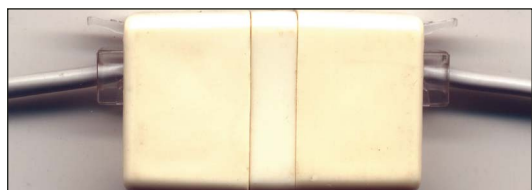
The instrument works flawlessly, but I do have a few comments about the effectiveness of the various sensors. I run several temperature devices on my weather pole and have found that the AAG temperature tends to run 2-10 degrees hotter than the others when the sun is shining. This is due in part to the fact that the unit has no ventilation and that the housing is made of white plastic so it creates a small solar oven inside. For this reason, I rarely use the AAG DS18S20 for temperature readings. The wind vane is ultra-sensitive to wind and never seems to stop turning. A bit more surface area and more mass is needed to make the vane more stable.

The AAG anemometer uses the following formula:

$$\text{MPH} = \frac{\text{counts over 1.5 second time period}}{.68}$$

Take a counter reading, wait 1.5 seconds, then take another. Subtract

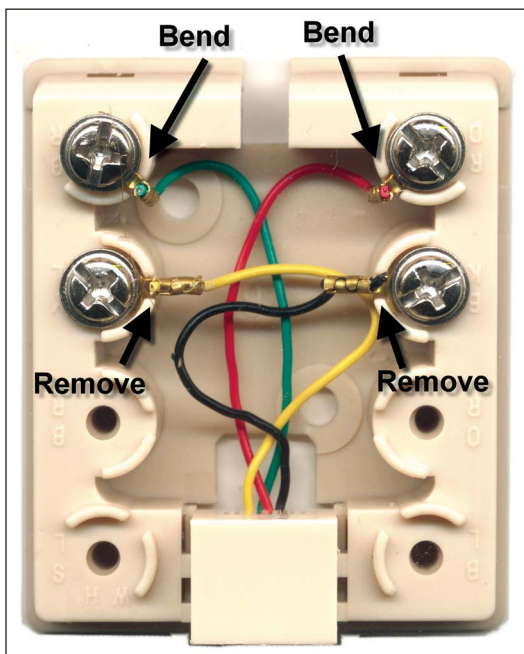
■ FIGURE 12



■ FIGURE 12



■ FIGURE 14



the first from the second. Multiply the difference by .68

Hookup

There are several ways of interfacing to the various sensors needed to build a weather station; the three most common are:

- PC to 1-Wire interface.
- PC to microcontroller interface.
- Microcontroller to 1-Wire/other.

Each has its advantages and as the series progresses, we will go into each type of system in detail. For this article, I will keep things simple and will be concentrating only on the PC to 1-Wire interface.

So far, most of what I have gone over relates to the mechanical construction or make-up of each unit. It is now time to hook up each unit and do some tests. In order to simplify things here, I chose to use a 1-Wire network for each of the three devices. This makes the actual software needed for each of the three nearly identical.

In order to connect 1-Wire devices to your PC, you will need a 1-Wire to serial adapter. A DS9097U is shown in Figure 11. They can be purchased for under \$30 and will allow your PC to connect to any 1-Wire device. I have added direct support for this adapter to Zeus. (Zeus is a custom program available on the Kronos website, which is listed under Links.) You will not need any drivers or runtimes to support it. All the test applications written for this article require this adapter and will not work with any others.

The AAG unit has two RJ12 connectors with only four of the six pins wired in each. One of these connectors will have a small jumper installed. For now, leave the jumper in place. An 8' coiled RJ11 cable was also included with the AAG. Plug one end of this cable into the remaining RJ12 connectors and plug the other end into the DS9097 adapter. This is all you need to do to start testing.

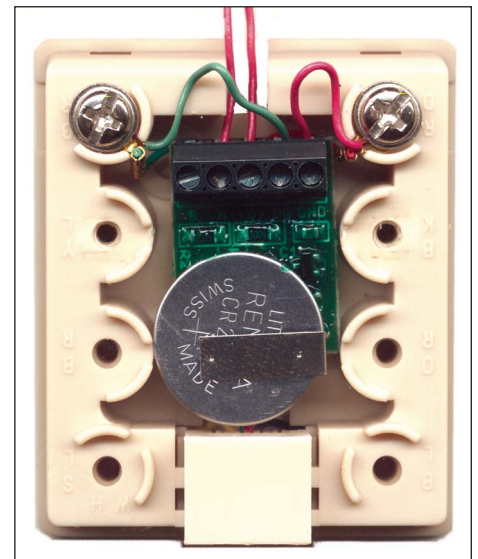
An important note is the cable that comes with the AAG instrument

is not the same as a standard telephone line cable. If you wish to use a normal telephone line cable, you will need an adapter. One way to do this is to use a line cable link and two line cables as shown in Figure 13. This will effectively allow you to connect two line cables, thus double-reversing the two center pins on the connectors.

The other two anemometers require a little more prep. As you recall, we are using a 1-Wire dual counter available from Hobby Boards as our interface.

In order to facilitate a connection to the PC, we will use a RJ11 surface mount box, available from most home centers. We are going to place the dual counter inside this box so make sure you get a standard sized box, not one of the small ones. In order to prep the box, you need to remove the yellow and black wires. The green and red wires will need to be bent as shown in Figure 14.

Cut a small length of wire, about one inch, will connect it to the box's green lug and then to the DQ terminal



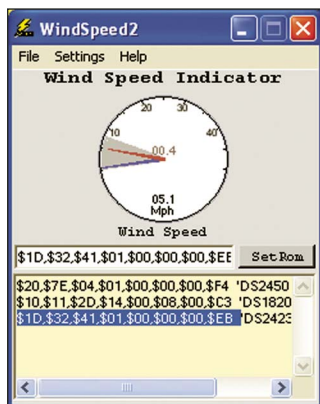
■ FIGURE 15

on the counter board. Cut another piece of wire and attach the red lug to the Gnd terminal on the counter board. You can now connect the anemometer reed leads to the 5V and A terminals as shown in Figure 15.

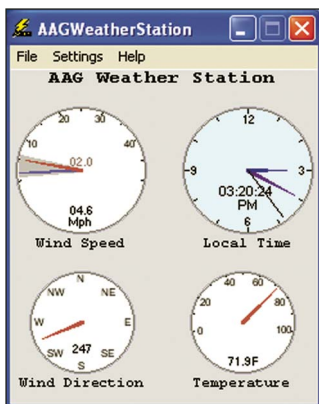
You can use a standard telephone

HOMEMADE ANEMOMETER PARTS

ITEM	PART NO.	SUPPLIER
<input type="checkbox"/> Anemometer Cup and Hub Assembly		Force Field
<input type="checkbox"/> Two Neodymium Magnets		Force Field
<input type="checkbox"/> Bearings	Team Associated #6589	Tower Hobbies
<input type="checkbox"/> Reed Relay	#275-232	RadioShack
<input type="checkbox"/> 1/2" PVC Cap		Home Centers
<input type="checkbox"/> 1/2" PCVTubing		Home Centers
<input type="checkbox"/> #4 1-1/4" Stainless Steel Machine Screw		Home Centers
<input type="checkbox"/> #4 Stainless Steel Washer		Home Centers
<input type="checkbox"/> #4 Lock Nut		Home Centers
<input type="checkbox"/> #5 Hex Nut		Home Centers
<input type="checkbox"/> 5/32" Brass Tube		Home Centers
<input type="checkbox"/> 3/16" Brass Tube		Home Centers
OTHER PARTS		
<input type="checkbox"/> Dual Counter	DC2.5-R1-A	Hobby Boards
<input type="checkbox"/> AAG Weather Instrument	WIND-R3-A	Hobby Boards
<input type="checkbox"/> AAG Weather Instrument Assembly Instructions		Hobby Boards
<input type="checkbox"/> 1-Wire to Serial Adapter	DS9097U-A	Hobby Boards
<input type="checkbox"/> AAG Weather Instrument	TAI8515	AAG Electronica
<input type="checkbox"/> 1-Wire to Serial Adapter	DS9097U	AAG Electronica
<input type="checkbox"/> Standard Anemometer Kit	WEA-ANKIT-A	Fascinating Electronics
<input type="checkbox"/> RJ11 Surface Mount	GETL26101	Home Centers



■ FIGURE 16



■ FIGURE 17

line cable to connect the surface-mount box to the DS9097 now and you are ready to test.

Testing

I have included a couple of programs for testing the anemometers. The first program called WindSpeed2 (shown in Figure 16) will allow you to test each of the anemometers presented in this article.

The first thing you will need to do is set the com port that you have connected to the DS9097 adapter. Use the Com Port

LINKS

- Hobby Boards: www.hobby-boards.com
- Fascinating Electronics: www.fascinatingelectronics.com/index.html
- Kronos Robotics: www.kronosrobotics.com/xcart/customer/home.php
- KRMicros: www.krmicros.com/Devel
- opment/ZeusPro/ZeusPro.htm
- AAG Electronica: www.aagelectronica.com/aag/
- Force Field: www.forcefieldmagnets.com
- Tower Hobbies: www.towerhobbies.com

option in the Settings menu. Next you will need to set the unique ROM registration number for the DS2423 connected to your anemometer. To do this, select the Search ROMs option in the Settings menu. The program will display all the ROM registration numbers for each Dallas device on the 1-Wire network. If no devices are displayed, you are not properly connected to the network. You will have to go back and check your connections, as well as your com settings. Once you have valid devices displayed, select the eight hex ROM numbers associated with the DS2423 and hit the SetRom button.

The program will begin collecting data from the DS2423 sensor and displaying the result via the gauge. Be sure to set the appropriate calibration factor for the particular anemometer you are using.

The WindSpeed program is unique in the fact that it constantly monitors the wind speed sensor and updates the various indicators by looking at the amount of time that has passed as it averages the various long-term and short-term readings. This allows instantaneous displays of readings down to .1 MPH.

Going Further

I have included a complete mini AAG weather station that monitors and displays all three sensors from an AAG instrument shown in Figure 17. The download for these applications can be found on the Kronos Robotics website at www.kronosrobotics.com/Projects/catchwind.shtml.

Also available and included at the site is the source code and Pocket PC versions of the software.

Zeus has a complete low level 1-Wire library using the DS9097 adapter. There are also several high-level libraries for interfacing to various sensors directly. I have also included some simple console-based programs to demonstrate this interface.

Next month, I will delve into the 1-Wire interface in more detail. We will look at additional environmental sensors, as well.

I have created a forum devoted to building weather stations and home automation. I will be posting additional projects, as well as update notices at www.kronosrobotics.com/forums/. **NV**

Hobby Boards

Your premier source for 1-Wire devices

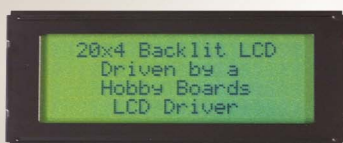
Many Uses:

Weather Monitoring
Home Automation
Garden and Yard Automation



Many Options:

Fully Assembled Devices
Boards, Kits and Parts
Cases



Our devices are featured in Wyle's Extreme Tech series Weather Toys by Tim Bitson. This book is available on our website.



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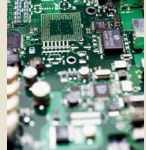
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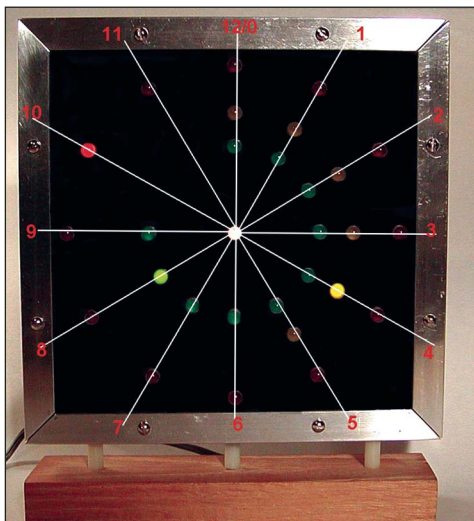


This clock project is a little bit different. It combines digital logic and modern electronic components with the traditional analog positional display (almost).

The approach lends itself to all sorts of variations so you can choose to make your clock in whatever way suits your taste.

It should be noted that while the example built only displays hours and minutes, the software (and schematic) fully supports hours, minutes, and seconds.

■ **PHOTO 1.** The clock has three hands: hours, tens of minutes, and ones of minutes, and is read outer ring inwards. The red LED indicates 10 hours. The yellow LED "points" to 40 minutes and the green LED shows eight minutes. This makes the time 10:48. If you incorporate the seconds, then the clock will have five hands.



THE DIGI-LOG CLOCK

The Three-Handed Clock

There is a simple technique to reading the clock. There are three "rings" of LEDs for the clock shown. The outer ring represents hours. The middle ring represents tens of minutes, and the inner ring represents individual minutes. There is only one LED per ring lit. The analog clock-face position of this LED indicates the value. Straight up (or topmost) is 12. Straight down is 6 and so forth. There are 12 positions for the hours, six positions for the tens of minutes, and 10 positions for the ones of minutes. In effect, the clock has three hands: hours, tens of minutes, and ones of minutes. The center LED is necessary to provide a visual reference in a darkened room. (I used a bi-color central LED that flashes back and forth between red and green.) Note that the "12" o'clock position indicates zero for anything other than hours. So 12:00 noon (or midnight) will have a line of LEDs straight up.

Looking at Photo 1, you can see that the time is 10:48. The red outer ring LED that's on is in the 10 o'clock position. The lit LED for the tens of minutes (yellow) is in the 4 o'clock position, and the ones of minutes (green) is in the 8 o'clock position.

If you choose to implement the

design to display seconds, there will be two additional rings for the tens of seconds and ones of seconds (identical in layout to the two minutes rings). In this case, your clock will have five hands: hours, tens of minutes, ones of minutes, tens of seconds, and ones of seconds. You will probably also have to make it physically larger to accommodate the two additional rings.

The design shown has the hours as the outermost ring. This is arbitrary. You can place your rings in any order you want. However, I like reading from the outside ring, inward. It seems more natural and the most significant digit has the biggest ring. I also used different colors for different rings for easier ring identification.

Design Approach

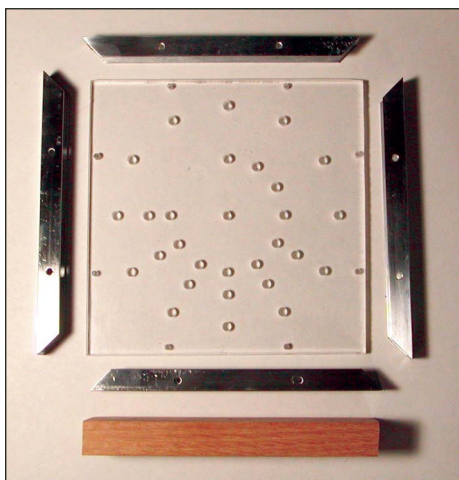
In order to keep the design simple and manageable, an LED matrix was used with a microprocessor (μ P). Instead of calling out rows and columns of a conventional matrix, we use rings and spokes for clarity. The rings have already been defined (hours, tens of minutes, etc.). The spokes are unit values (0-9 for minutes, 0-5 for tens of minutes, etc.). By driving one ring and one spoke, a single LED can be made to light up. The actual design does this very quickly (a standard technique called multiplexing) so it appears that several LEDs are on at one time. Using a matrix significantly reduces the number of wires and microprocessor I/Os needed. In this case,

NOTE:

The source code for the software is available on the *Nuts & Volts* website at www.nutsvolts.com.

The resistor values for the LEDs are not specified because they depend on the brightness of LEDs you use. I used really old and inefficient diffused LEDs so R4 through R8 were 100 ohms. If you use high-brightness LEDs, you may choose to increase these resistors to 510 or even 1,000 ohms. This is especially true if you use high-brightness, point-source LEDs. Note that the clock-display LEDs have a 20% duty cycle and the center LED has a 100% duty cycle (50% red and 50% green).

■ **FIGURE 1.** The clock design is very simple consisting mostly of a microcontroller and LEDs. The tens of seconds ring and the ones of seconds rings (D29-D44) are optional and can be omitted if you only want to display hours and minutes (like this project).



■ **PHOTO 2.** The main hardware parts are a 1/4" thick plexiglas face, aluminum channel frame, and oak base. Feel free to choose other materials and methods to suit.

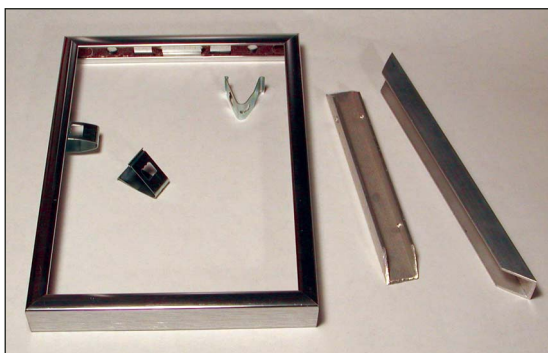
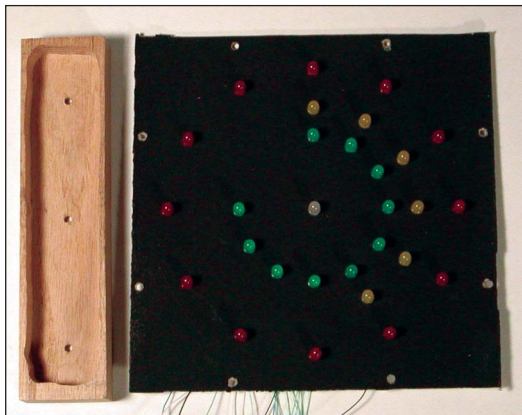
Be sure to limit the current such that the μP isn't exceeding the design limits (about 25-35 mA per I/O).

Hardware Design

This is the most difficult and most personal. How you put it together is really completely up to you. Choose any method or style you like. I chose 1/4" thick plexiglas for the face, stock aluminum channel for the frame, and oak for the base. The dimensions (as shown) are 7.8" tall, 6.6" wide, and 1.5" deep (at the base).

The main parts are shown in

■ **PHOTO 4.** The base is hollowed out with a router to hold the electronics. The "circuit board" for the LEDs is just a piece of cardboard from a writing pad that was spray-painted flat black.



■ **PHOTO 3.** The frame for this project were fabricated from stock aluminum channel. If you don't want to do that, a thick picture frame with holding clips can be used instead.

Photo 2. Holes were drilled in the plexiglas for the LEDs. They protrude slightly from the face. If you want a flat face, use thicker plexiglas, smaller LEDs, or mount the LEDs farther back. The aluminum channel I used was about 5/8" wide and 1/2" deep (outside measurements). The wall thickness is 1/16" thick.

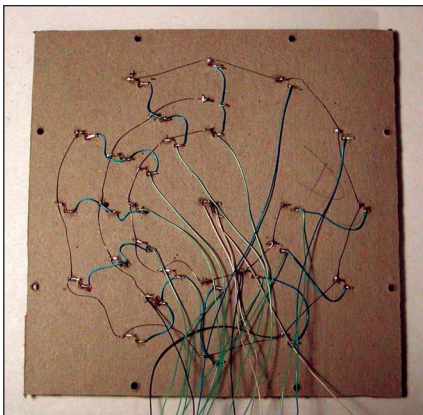
Photo 3 illustrates the channels, as well as a commercial picture frame. These thick picture frames use clips (shown) to hold everything in place. Using such a frame will probably save time and effort. You should still use plexiglas (or other clear plastic) for the face, instead of the glass that comes with the frame. But it will probably have to be thinner than 1/4". Additionally, because the frame is rectangular you will have to determine the best LED layout. (Of course, you could use this non-display space for the electronics and eliminate the base. Then you would have a clock you could hang on the wall.)

Instead of a real circuit board, I used a piece of cardboard from the back of a writing tablet that I spray-painted flat black. This is shown in Photo 4. Note that the plastic face was drilled

first and then the LEDs were placed to fit. Using cardboard made this really easy. I just put the face over the cardboard and pressed an awl through the holes in the plastic to make holes in the cardboard for the LED leads. Standard diffused LEDs of T1 3/4 size (0.20" diameter and 0.34" long) with 0.100" lead spacing were chosen because they were easily available. Photo 4 also shows how the oak base was routed out about 0.6" to accept the electronics.

Wiring the Clock

I used point-to-point wiring for everything. Photo 5 displays the back of the cardboard "circuit board" that held the LEDs. I bent the LED leads flat to hold them in place for wiring. After assembly, the holes in the plastic face keep the LEDs in precise position. It's easy to see the rings and spokes. I used bare wire for the rings and #30 wire-wrap wire for everything else. I incorporated different color wires to help identify what went where. I brought out the 18 wires (15 wires for the 12 spokes and three rings plus three wires for the bi-color LED) through the center hole and through a hollow spacer into the routed-out oak base. Photo 1 shows the clock display raised over the base with three 1/2" spacers. The outer spacers have 4-40 screws that connect the base to the display. Additionally, these screws extend into the base to hold the electronics circuit board in



■ **PHOTO 5.** Number 30 wire-wrap wire was used for the rings and spokes. The LED's leads were bent over to hold the LEDs in place, next the wires were soldered, and then the leads were trimmed. Keeping the leads long during soldering helps to dissipate the heat which can damage the LEDs.

place. Photo 6 shows the mounting screws holding the circuit board in place. The wires from the display come into the base from the middle spacer, exit under the circuit board, and come around its edge. Some of this can be seen in the photo.

There are several notes concerning Photo 6. The three large black objects with white stripes are connectors. If you look closely, you can see the wire-wrap wires connecting to them. This made it easy to disconnect the circuit board from the display during de-bugging. The power supply is at the top with the power jack coming out the back of the base just below this. At the bottom, there are two push-button switches (SW1 and SW2) that are used for setting the time. Not seen are the LED current limiting resistors (R4-R10). These are mounted on the bottom of the circuit board because it made things easier for me.

Operation

Operation is simple and straightforward. Apply power to the clock. After about a second, the clock should display 12:00 (12:00:00 if seconds are used) and should immediately operate. Pressing the Set Minute switch (SW1) will increment the minutes display every time it is pressed. At worst case, you will have to press it 59 times to set it to the proper minute. Holding it down does NOT continuously increment the display (but that is a software upgrade you could write!) If the minutes display passes through the hour (59 minutes to 00 minutes), the hour display is NOT incremented (as it would in normal operation). Setting the hour is accomplished by pressing the Set Hour switch (SW2) in a similar manner. Each switch press increments the hour display. There is no provision for setting the seconds. However, since the time-keeping continues during the setting of the clock, the seconds can be "set" by applying power exactly on the minute (because the clock power on reset initializes itself to exactly 12:00:00). The seconds are not affected during the

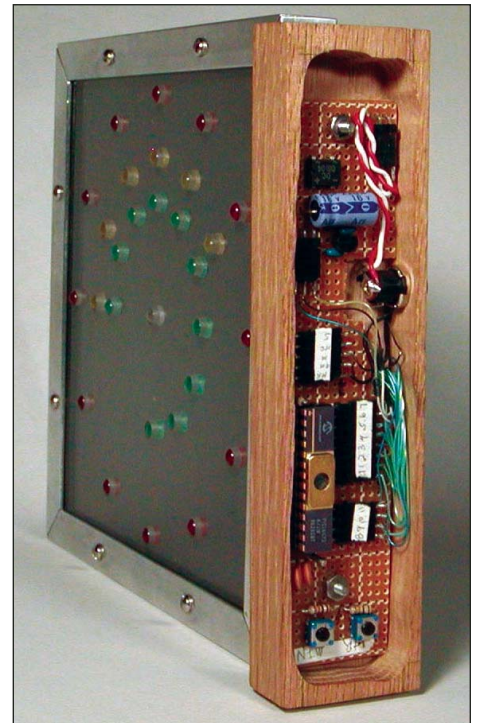
■ **PHOTO 6. Final assembly of the clock.** The two small switches at the bottom are used to set the hours and minutes. Connectors were used for the display wires for easier troubleshooting.

setting of hours and minutes.

The accuracy of the clock depends upon the accuracy of the watch crystal. These are typically tuning-fork types with a basic tolerance of 20 PPM (Parts Per Million). Since there are about 2.6 million seconds per month, an error of 20 PPM converts to an error of about eight seconds per month, worst case.

Going Farther

It has been noted that the display looks similar to the planetary motions of the solar system. You could design a clock that shows the relative movements of the planets by having each ring represent a planet's orbit and use separate timers for each ring/orbit. You could also get fancy and show the absolute positions of the planets by adding a new display for the year, month, and day. In this way, you could pick a date and see exactly where the planets would be in the sky at that time (in the past or the future).



Conclusion

A different type of clock has been designed that integrates digital and analog concepts. It's simple to build and operate. Additionally, there are many different ways to customize the clock to match your preferences. **NV**

PARTS LIST

RESISTORS (1/4 watt 5%)

- R1-R3 10K ohms
- R4-R10 100 to 1000 ohms (see text)

CAPACITORS (25 volts minimum)

- C1, C2 33 pF
- C3 220 μ F
- C4, C5 0.1 μ F

SEMICONDUCTORS

- D1-D44 LED (see text)
- D45 Center LED bi-color (see text)
- D46 Bridge rectifier 1 amp 50 volts
- U1 PIC16C73A microcontroller
- U2 78L05 low power five volt regulator

MISCELLANEOUS

- X1 32,768 Hz watch crystal
- SW1, SW2 Normally open push-button switch (SPST)
- J1 DC power jack



WALL-WART-LESS AVR PROGRAMMER USER/MAKER

46 NUTS AND VOLTS February 2007

user, it can also program the eight-pin AT90S2323/2343 and the 40-pin AT90S4414/8515).

First let's see how wall-wart-lessness can be achieved. The basic requirement is that the total current consumption by the circuit must be very small, such as less than 10 milliamps, because the UART port was never designed as a power source like the USB port we have today. The two pins DTR (data terminal ready) and RTS (request to send) can be used as a minuscule power source if we treat them wisely and choose appropriate components.

As shown, the outputs from these pins are delivered to a pair of Schottky diodes D1, D2 — which cause very little forward voltage drop (only 0.3 volts) — then applied to a low-dropout voltage regulator LM2936; their output voltage is smoothed by two capacitors C1 and C2. To save current consumption, the LED circuit also uses a bigger current-limiting resistor (1K), and the control firmware will turn it on only after the programming task has completed and is in idle state. Otherwise, the LED is set OFF.

From Figure 1, it's apparent that the circuits for programmers are easy to build. The circuit for the WWLHTP-1 is simplest; it utilizes the Atmel 8051-like micro AT89C2051/4051 which has 2K/4K bytes of program memory. It doesn't need any component connected to the RESET (pin 1) and it uses the 3.58 MHz ceramic resonator to generate 19200 bps for communication.

The circuit for WWLHTP-2 utilizes the Atmel AT90S2323 AVR MCU which contains 2K bytes of program memory. It does need two components R2 and C3 connected to the RESET pin as shown by the dotted lines. Missing either one will result in failure or not completely working. It uses the 4 MHz ceramic resonator for the same 19200 bps.

We guessed that when Atmel designed the AT90S2313 they might keep the 4051 MCU in mind so that both look very similar (same pin count, same RX, TX and XTAL pin locations). That helps us to utilize both almost

interchangeably, even though each MCU is quite different in their architecture and uses a different machine or assembly language.

All AVR MCUs have the three-pin SPI (serial peripheral interface) port to be used in their serial programming. The chip to be programmed is called a "slave" and the control MCU or host processor is called a "master." In programming mode, the SCK pin is used to transfer the clock signal from master processor to slave for synchronization control. While MISO is the signal from slave to master, MOSI is the signal from master to slave.

Firmware and Example Programs

Table 1 lists the hex files contained on the programmer user's disk. The first two are most important: they are each programmer's firmware files. As you may know, firmware is the code stored in a microcontroller for its execution. The programmer firmware contains the execution code on how to communicate with the PC, and all the nine programming commands which interact with the Windows HyperTerminal program.

Note that because the 2051/4051 is an 8051-like MCU, its machine or assembly language is different from AVR. Therefore, you should pay close attention to what the target MCU is for each file, and never mix them up.

By the same reason, the two example program files LED1AVR.HEX and LED2AVR.HEX are supposed to be written or "burned" in AT90S1200/2313, and then you temporarily replace the existing firmware MCU by this newly programmed MCU. Once powered up, you will see the LED blinking or double blinking. In other words, you don't have to build your own circuit to test this program, but rather use the programmer itself. This is

File Name	Target	Purpose
WWLHTP1.HEX	AT89C2051/4051	WWLHTP-1 firmware
WWLHTP2.HEX	AT90S2313	WWLHTP-2 firmware
LED1AVR.HEX	AT90S1200/2313	Use for Demo
LED2AVR.HEX	AT90S1200/2313	Use for Demo

■ TABLE 1

a great convenience for the user. Not every programmer has this feature.

Because a blank AT90S2313 is a device to be programmed (as U3 in Figure 1) and we can enter not only LED1AVR.HEX or LED2AVR.HEX but also WWLHTP2.HEX, it is interesting to point out that this firmware file can also be regarded as a special "example program."

But there is an exception. This newly programmed 2313 can only be demonstrated on the WWLHTP-2 circuit; it can't be demonstrated on the WWLHTP-1 circuit, because the components R2, C3 and 4 MHz ceramic resonator are not in the WWLHTP-1 circuit.

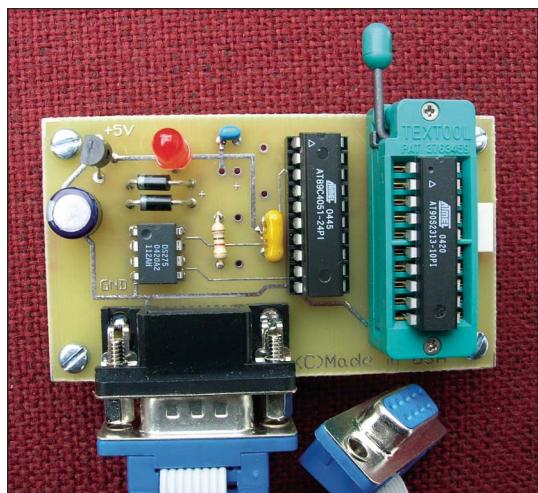
From this comes an important conclusion: You have a chance to be a WWLHTP-2 programmer maker! You can burn as many blank AT90S2313s as you want, simply by using either the WWLHTP-1 or WWLHTP-2 programmer.

On the other hand, you cannot make another WWLHTP-1 programmer unless you have a way to program the 2051/4051 (for example, using the 8X51 programmer [2]). The AVR wall-wart-less programmers here can't do that. So it may be better for you to have a WWLHTP-1 first if you're going to get one, because from WWLHTP-1, you can make WWLHTP-2, but not vice versa.

The Options

Because WWLHTP-1 and WWLHTP-2 are different only on the processors, their speed and functionality are the same, so the factors that influence your choice are your budget, your preference, and your familiarity with that processor.

Only one type of business-card-sized PC board was designed to fit both forms of programmers, with some

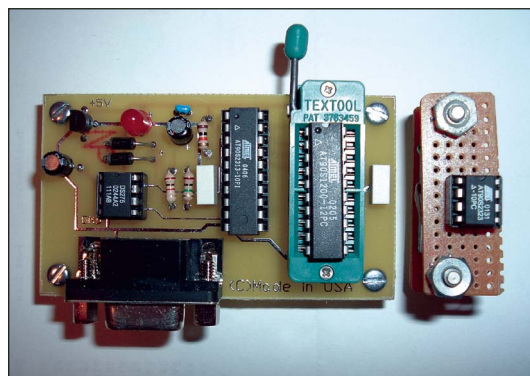
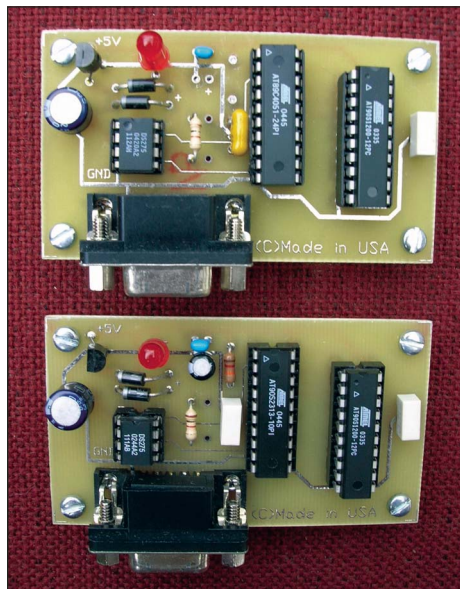


■ **FIGURE 2. Deluxe WWLHTP-1 programmer.**

holes left empty. Figure 2 shows the deluxe version of WWLHTP-1. Notice that there is no power plug on it—that's wall-wart-less. It's better to make a two to three foot flat ribbon DB-9 cable (as shown) to carry this small gadget. When you need to use it, simply plug the cable into the PC's serial port.

Figure 3 is the deluxe WWLHTP-2 programmer, together with a hand-made adapter built by the user. (You can refer to my previous article for the schematic on building an adapter.) The basic requirement is to connect the SPI pins (SCK, MISO, and MOSI) and the Vcc and GND pins properly.

■ **FIGURE 4. Economy HyperTerm programmers.**



■ **FIGURE 3. Deluxe WWLHTP-2 programmer. Right: adapter for the eight-pin AT90S2323/2343.**

Figure 4 shows the economy version of the two programmers, respectively. Sometimes the serial cable can be eliminated if your PC/laptop allows you to directly plug this gadget in. The only restriction to using the economy version is flexibility; you won't be able to handle the eight-pin or the 40-pin AVR's. However, the lower cost and convenience are great advantages, especially for beginning users. With the AT90S1200/2313, you can do a lot of programming, including making your own AVR programmer, as described below.

If you want to save some bucks or just want to tinker around, use your available junk box components and a palm-sized solder-less breadboard to build either the WWLHTP-1 or WWLHTP-2, as shown in Figure 5.

Be a Programmer User/Maker

As mentioned above, by using the wall-wart-less AVR programmer, you can make as many WWLHTP-2 pro-

grammers as you want.

To run the wall-wart-less AVR HyperTerm programmer, you must properly set up the Windows HyperTerminal program on your PC/laptop, as described in my previous article. Let's briefly recap some of the most difficult parts of this as it can be difficult for beginners.

Begin from the Windows "Start"

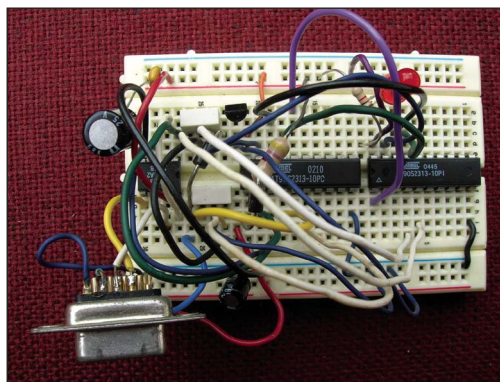
button, find Accessories> Communications>Hyperterminal and double-click it. A lot of dialog boxes will appear asking for Location information or a phone number. Reject all default offers and continue, until you reach "New Connection." The dialog box then asks you to enter a Name and choose an Icon. Type in a name (such as T19200), select an icon, then click OK.

After that, the Location information prompt appears again. Reject it one more time. The "Connect to" dialog box appears, where there is an item "Connect using ..."; you can then find the serial port COM1. Select it and click OK. Immediately the "Port setting" box appears. From there, select the baud rate and other parameters to match the programmer: 19200, 8N1; remember to select XON/XOFF for "Flow control" (reject default "Hardware"). Click OK.

A rectangular window will pop-up with the "File" menu bar and a cursor resting at the upper-left corner. Click "File" menu and go to its "Properties" item. From there, edit the "Settings"

tab so that the Emulation type is TTY; then go to the "ASCII setup" box, where it has a portion called ASCII sending. Put a check mark in the box for "Send line ends with line feeds." The reason for doing this is to send/receive ASCII characters using the serial COM port.

At this point, we're almost done. Notice that there are two



■ **FIGURE 5. WWLHTP-1 or WWLHTP-2 built on a breadboard.**

boxes along ASCII sending: Line delay and Character delay, with the number "0" in each. That means the line delay is 0 milliseconds for each item. To guarantee it works from the first time, it's better to put a value 1 instead of 0. If later you find it too slow, you can change the value back.

Before exiting from the "File" menu, you should save whatever you've entered, and create a short-cut icon for the COM port on your desktop, so you won't have to do this again.

When you connect the DB-9 cable to the PC, a menu appears on the rectangular window as shown in Figure 6. Now you're in business.

All commands start with the control key. For example, pressing ctrl-R will Read Flash memory, ctrl-E will Erase the chip. The most complicated operations are ctrl-W and ctrl-V, to

■ **FIGURE 6. Screen view when the programmer is run.**

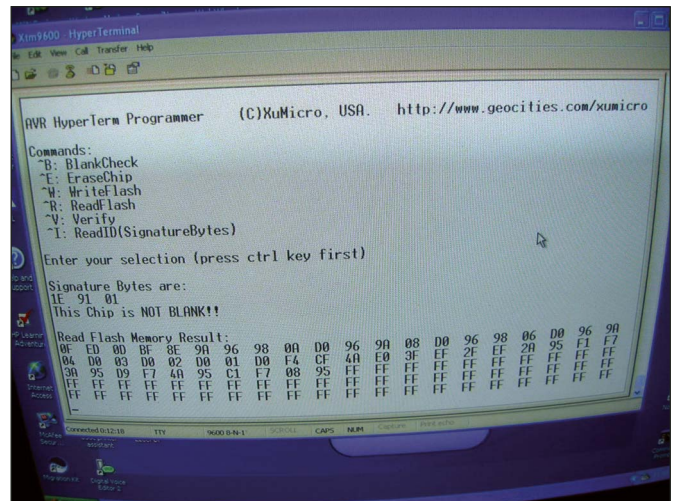
Write a Hexfile (Hexfile is also a text file or ASCII file) to the chip and Verify programming.

Keep in mind that our goal is to use the serial COM port to send/receive ASCII characters. You need to use the "Transfer" item from

the menu bar, and click the "Transfer Text File" menu from it. Type in a file name, such as LED1AVR.HEX, and press Enter or click "Open" to let it transfer. When the operation is fin-

ished, a completion message will display.

Good luck and enjoy using and programming your wall-wart-less AVR programmer. **NV**



SOURCES

■ [1] G.Y. Xu: "Play the AVR Hyper Term," *Nuts & Volts*, February 2005. (Article available on the *Nuts & Volts* website; www.nutsvolts.com)

■ [2] G.Y. Xu: "8X51 EPROM/Flash Microcontroller Programmer," *Circuit Cellar*, April 1998.

Note: The following items are available from:

G.Y. Xu
P.O.Box 14681
Houston, TX 77021
Phone: (713) 741-3125

■ Assembled and tested WWLHTP-1 Programmer — \$39.95 (Deluxe); \$29.95 (Economy).

■ Assembled and tested WWLHTP-2 Programmer — \$39.95 (Deluxe); \$29.95 (Economy).

■ Plated through hole PCBoard — \$8.00

■ Programmed AT89C4051 or AT90S2313 — \$5.00

Shipping and handling: \$5.00 (USA); \$6.00 (Canada); \$10.00 (other countries). For more info, visit www.geocities.com/xumicro.

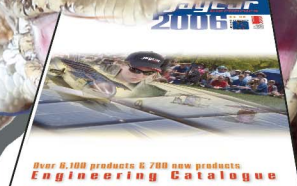
WWLHTP-1 PARTS LIST

ITEM	DESCRIPTION
□ C1	100 μ F 16-volt radial electrolytic capacitor
□ C2	.1 μ F ceramic capacitor
□ R1	1K ohm 1/4 watt carbon resistor
□ U1	RS-232 transceiver DS275 by Dallas Semiconductor
□ U2	AT89C4051 Flash microcontroller (programmed)
□ U3	AT90S1200 or AT90S2313, AVR MCU to be programmed
□ VR1	LM2936 voltage regulator
□ D1, D2	Schottky diode 1N5817
□ J1	DB9F connector
□ LED1	General-purpose light-emitting diode
□ CR1	3.58 MHz ceramic resonator
□ CR2	4 MHz ceramic resonator

WWLHTP-2 PARTS LIST

ITEM	DESCRIPTION
□ CC1	100 μ F 16-volt radial electrolytic capacitor
□ C2	.1 μ F ceramic capacitor
□ C3	10 μ F 16-volt radial electrolytic capacitor
□ R1	1K ohm 1/4 watt carbon resistor
□ R2	10K ohm 1/4 watt carbon resistor
□ U1	RS-232 transceiver DS275 by Dallas Semiconductor
□ U2	AT90S2313 Flash microcontroller (programmed)
□ U3	AT90S1200 or AT90S2313, AVR MCU to be programmed
□ VR1	LM2936 voltage regulator
□ D1, D2	Schottky diode 1N5817
□ J1	DB9F connector
□ LED1	General-purpose light-emitting diode
□ CR1, CR2	4 MHz ceramic resonator

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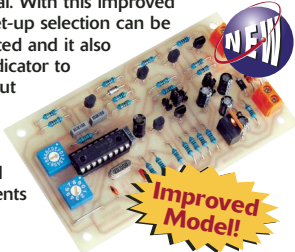
Max weight 12lb (5kg). Heavier parcels POA. Minimum order \$25.

Note: Products are dispatched from Australia, local customs duty and taxes may apply.

Speedo Corrector MkII

KC-5435 \$29.00 + post & packing

When you modify your gearbox, diff ratio or change to a large circumference tyre, it may result in an inaccurate speedometer. This kit alters the speedometer signal up or down from 0% to 99% of the original signal. With this improved model, the input set-up selection can be automatically selected and it also features an LED indicator to show when the input signal is being received. Kit supplied with PCB with overlay and all electronic components with clear English instructions.



Improved Model!

Magnetic Cartridge Pre-amp

KC-5433 \$23.25 + post & packing

This kit is used to amplify the 3-4mV signals from a phono cartridge to line level, so you can use your turntable with the CD or tuner inputs on your Hi-Fi amplifier. The design is suitable for 12" LPs, and also allows for RIAA equalization of all the really old 78s. Kit includes PCB with overlay and all electronic components.

• Requires 12VAC power



PowerTool Battery Charger Controller

KC-5436 \$23.25 + post & packing

Enhance the performance of the charger supplied with your power tool with this controller. It incorporates charge timeout, min and max temperature monitoring, Delta V charge detection, power and charge LED indicator and more! Suits both Ni-Cd and Ni-MH cells. Kit includes PCB with overlay, case and all electronic components.



Two-Way SPDIF/Toslink Digital Audio Converter Kit

KC-5425 \$14.50 + post and packing

This kit converts coaxial digital audio signals into optical or vice-versa. Use this bit stream converter in situations where one piece of equipment has an optical audio input and the other a coaxial digital output. Kit includes Toslink optical modules, PCB with overlay, case with screen printed lid, all electronic components and clear English instructions.



Requires 9-12VDC wall adapter (Jameco#252751 \$12.05)

Starship Enterprise™ Door Sound Simulator

KC-5423 \$23.25 + post & packing

This easy-to-build kit emulates the unique noise made when the cabin doors on the Starship Enterprise™ open and close. The sound emulator can be triggered by switch contacts (normally open), which means you can use a reed magnet switch, IR beam or PIR detector. Kit includes a machined, silkscreened and pre-drilled case, speaker and all electronics components with clear English instructions.

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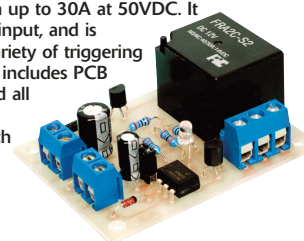
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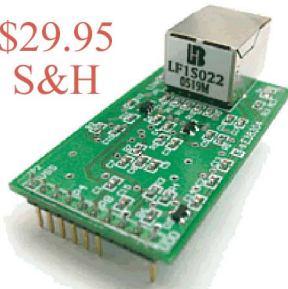
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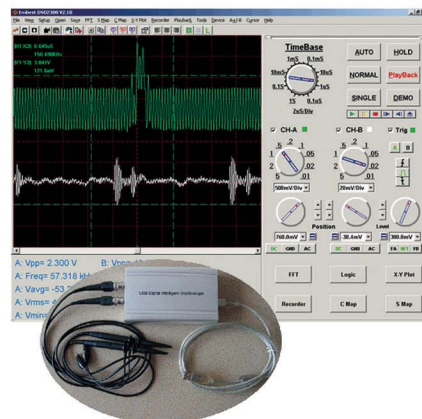
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iNterface Your iPod

With all the aftermarket products available for the iPod these days, it makes you wonder if you can't hack into the iPod yourself and build your own iPod gizmos. Yes you can! With the dock connector, the iPod can be charged, connected to a PC, connected to a stereo, or connected to a serial device and controlled via the Apple Accessory Protocol. Here is a quick overview of the docking connector and ways to utilize it.

by TJ Byers

Overview

In a nutshell, the Apple iPod is a personal MP3 player, about the size of a deck of cards, that is capable of storing thousands of tunes on its internal hard drive. It connects to Apple Macintosh computers equipped with a FireWire interface (all modern Macs) and syncs with Apple's iTunes 2 (free) MP3 Player/Encoder/Organizer application.

However, the iPod also doubles as a portable hard disk drive that can be used for traditional data storage. It can even be used as

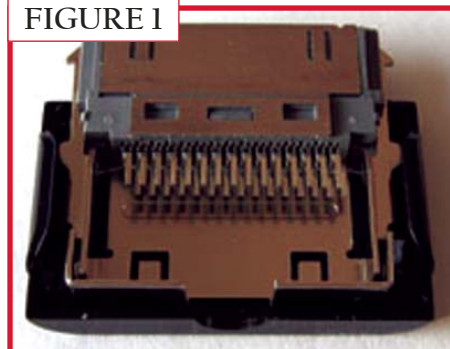
a boot volume. The interface types include FireWire, USB, TTL serial, audio, and video ports.

Docking Connector

The dock connector was introduced with the third generation iPods. The connector is proprietary (Figure 1) and manufactured for Apple by JAE (Japan Aviation Electronics). Until recently, you had to contact Apple, sign a Non-Disclosure Agreement and jump through hoops to obtain the mating connectors for the iPod. Fortunately, you can now find them from the following suppliers for about \$2 each.

- Ridax — (646) 257-2080, <http://home.swipnet.se/ridax/connector.htm>
- Spark Fun — www.sparkfun.com/commerce/product_info.php?products_id=633

FIGURE 1



FireWire

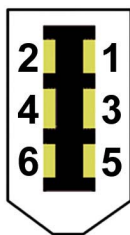
FireWire is the trademarked name of Apple Computer for the IEEE-1394 personal computer — and digital audio/digital video — serial bus interface. Virtually all modern digital camcorders have included this connection since 1995, as well as many portable computers, including all Apple, Dell, and Sony laptops (where it is known as i.Link).

The iPod uses a six-pin connector for the FireWire link (Figure 2). Pins 1 and 2 are used to charge the iPod's internal battery via a 12-volt source. The data is transferred via two twisted pairs using CAT-5 cable or any of several ready-made FireWire cables. Typically, you load the music or video file into the computer, then transfer it to the iPod using the FireWire connector at data rates of 100, 200, or 400 Mbps, depending on the particular model, using Apple's software. This doesn't prevent you from using the FireWire port with other devices — like video editors — using their software.

USB

The iPod supports the more popular and widespread USB 2.0 Universal Serial Bus, using the type A connector (Figure

FIGURE 2



Pin	Description
1	+12V
2	GND
3	TPB-
4	TPB+
5	TPA-
6	TPA+

FireWire
Connector

3). Like FireWire, USB is a digital serial bus. It uses four shielded wires: two for power (+5V and GND) and a twisted pair data cable (D+ and D-) at 480 Mbps. Unlike FireWire, the power connections are power out, and cannot be used to charge the iPod's internal battery.

The USB was designed to connect peripherals such as mice, keyboards, scanners, digital cameras, printers, hard disks, and networking components to the PC, and became an early iPod interface for Window-based PCs. Because of its popularity, you will find more USB supported devices than you will FireWire devices.

Serial Port

The Serial Port lets you transfer data between the iPod and any TTL serial device — like a printer — using the Apple Accessory Protocol. The connections uses a standard 8N1 serial protocol. Although the port speed is specified at 19.2K baud, the port will work at speeds up to 57.6K baud — with caution. No dedicated connector is specified.

To interface the iPod Serial Port to an RS-232 PC port, you need a converter, like the one shown in Figure 4. At the heart of the circuit is a MAX232A integrated circuit that contains a switched capacitor ± 10 -volt step-up voltage converter. These voltages power four buffers that translate the RS-232 positive/negative voltage swings into five-volt TTL/CMOS levels.

FIGURE 6

4-Pin Mini DIN

Pin	Description
1	GND
2	GND
3	Luminance
4	Chrominance

S-Video Connector

Audio

The dock connector provides access to both audio input and audio output at line levels. Like most consumer products, the iPod output line level is rated -10 dBV, which corresponds to a signal of about 0.3162 volts RMS. Unlike the earphone jack, this audio signal is taken before the built-in headphone amplifier and has a wider bandwidth with crisper sound. This signal is typically plugged into amplified speakers for room listening.

The volume level is also unaffected by the iPod's volume control and remains steady even with the control

USB Type A Connector

Pin	Description
1	+5V
2	D-
3	D+
4	GND

FIGURE 3

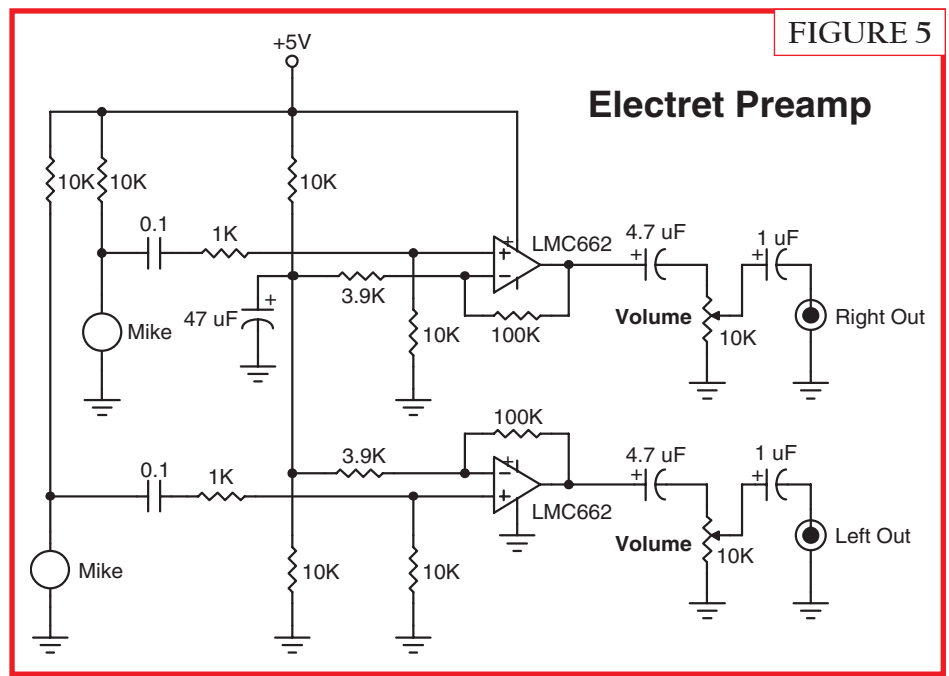
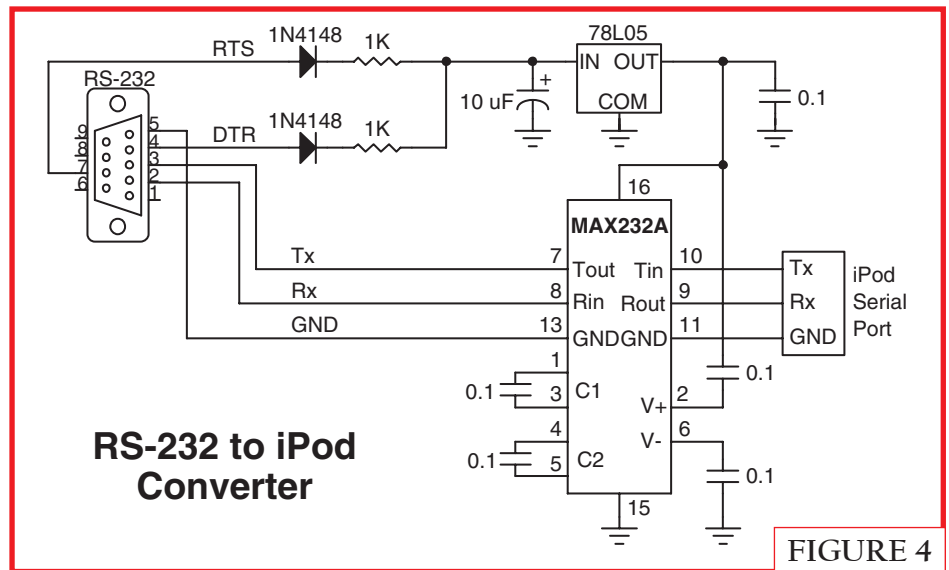
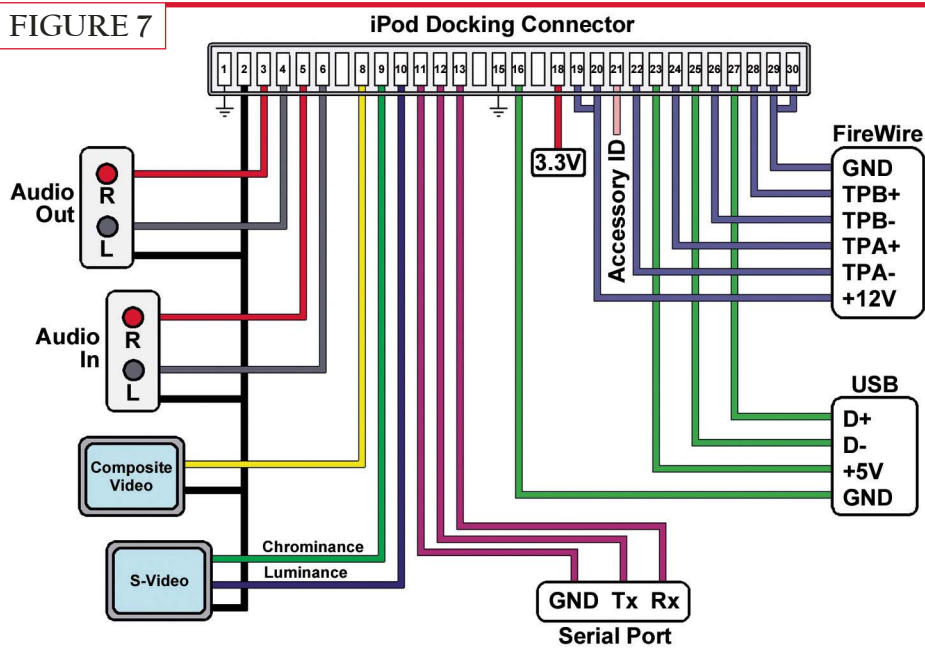


FIGURE 7



turned all the way down. The audio in is also at line level, and needs a preamp if it is to be used with a microphone. A simple preamp is shown in Figure 5. Pin 2 of the Dock Connector is signal return ground for both the audio and video.

Video

The iPod Dock Connector has two video outputs: composite and S-Video. The composite video is the same as

that used for TV broadcast and displayed on an analog TV set. Almost all modern video equipment has a composite connector, so there isn't usually a problem of simply plugging this output directly into the video device. However, older video equipment and some very low-end modern televisions have only an RF input (antenna) and won't accept the signal without an RF modulator, like the CAT# MOD-6 from All Electronics (888-826-5432; www.allelectronics.com).

Resistance	Accessory
1K	Beeps when docking station is connected.
10K	Places iPod into Photo Import Mode.
500 K	Denison Ice Link Plus car interface.
1 Meg	Belkin auto adapter.

TABLE 1. Accessory Indicator.

allelectronics.com). The modulator converts the composite signal into an RF signal on channel 3 or 4 for display on the TV screen.

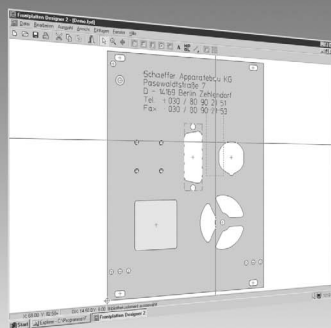
S-Video is an analog signal composed of luminance (intensity) and chrominance (color) components. The four-pin S-Video connector (Figure 6) was designed for Super VHS VCRs as a high-bandwidth video connection, and has since been used with TVs, DVD players, high-end video cassette recorders, Digital TV receivers, DVRs, and game consoles — coming into greatest prominence with the rise of the DVD format. Due to a lack of bandwidth, though, S-Video is not generally considered suitable for high-definition (HD) displays.

Accessory ID

A resistor connected from this pin to ground indicates which accessory is connected. Table 1 is a short list of those accessories that I know about. **NV**

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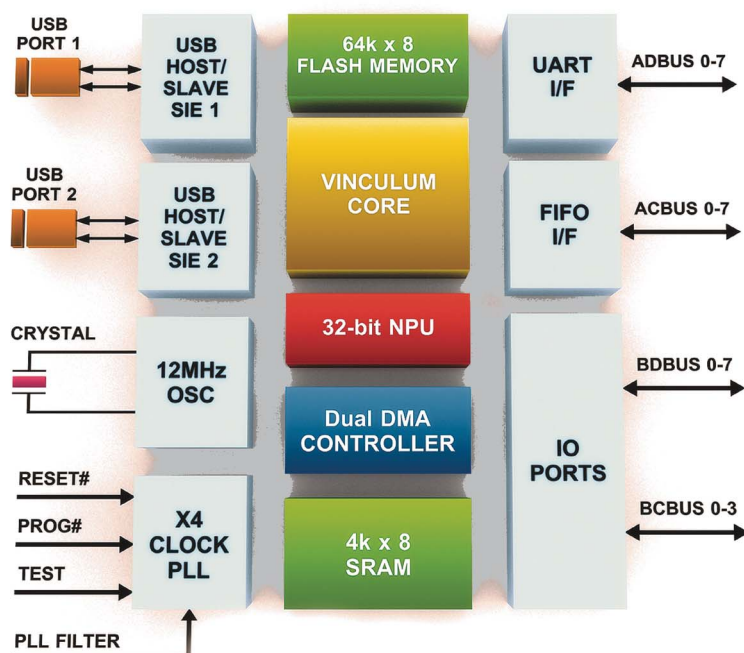
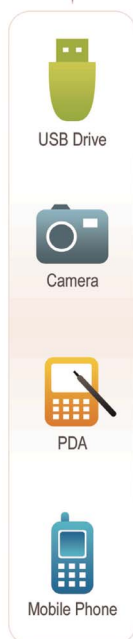
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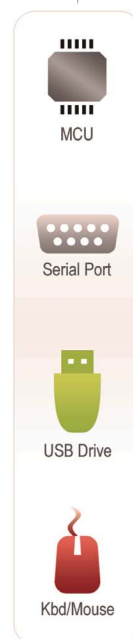
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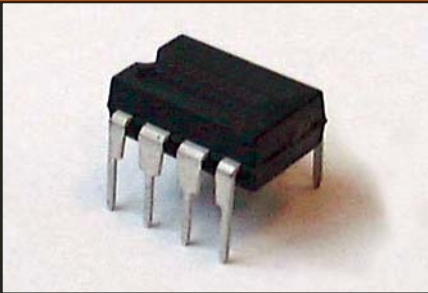
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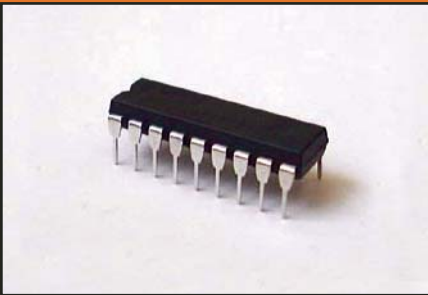
PART 2

by Ron Hackett

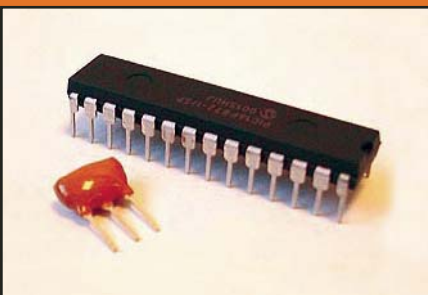
The PICAXE-08M Chip



The PICAXE-18X Chip



The PICAXE-28X Chip



The PICAXE-40X Chip



In Part 1 of this series, we introduced the PICAXE-18X microcontroller, provided a brief introduction to PICAXE programming, and constructed a simple “Hello World” project to demonstrate the simplicity of the PICAXE system. As promised, in Part 2 we will focus on **interfacing the PICAXE-18X with a Hitachi HD44780-based LCD display**. Finally, in Part 3, we will add a 12 or 16 key matrix keyboard and a piezo beeper to complete our I/O terminal.

At the end of Part 1, we added an input switch to our “Hello” circuit and posed a challenge to write a program to control the blinking of the two LEDs

with the switch without using the PICAXE “Button” command; each time the switch is pressed, the LED that is currently lit should turn off and the

FIGURE 1. One possible solution to the programming challenge.

```
' **** HelloButton.bas ****
'
' This program runs on a PICAXE-18X at 4 MHz.
' It toggles LEDs on outputs 6 & 7 in response to a switch-press.
' ****
' **** Constant Definitions ****
'
symbol LED6 = output6      ' LED on output6 (pin 12)
symbol LED7 = output7      ' LED on output7 (pin 13)
'
symbol pbsw = input2        ' push-button switch on input2 (pin 1)
symbol up = 0               ' input2 held to Ground when switch up
symbol down = 1             ' input2 goes high when switch pressed
'
' **** Main Program ****
'
high LED6                  ' start with LED6 turned on
                             ' (& LED7 turned off by default)
main: if pbsw is up then main ' loop here until switch press
                             ' note: "is" is equivalent to "="
'
toggle LED6                ' switch pressed, so toggle LEDs
toggle LED7
pause 25                    ' delay 25mS to avoid switch-bounce
'
tarry: if pbsw is down then tarry ' loop here until switch release
'
goto main                  ' do it again, forever
```


Getting Started With PICAXE Microcontrollers

other LED should turn on. Of course, there may be as many correct answers as there are readers, but one possible solution is presented in Figure 1.

The most important aspect of any solution is to avoid the “extra” switch presses generated by switch-bounce, and the simplest way to do so is to delay long enough for the switch contact to “settle” (usually within 25 ms or so). The loop that waits for the switch to be released (near the end of the program in Figure 1) is also important; without it, the program will respond to a single switch-press as if it were a rapid series of presses. The bottom line is: If your program functions as expected and it’s reasonably easy to understand, then it’s a correct solution — congratulations!

We won’t be using switch-presses in this part of the series, but we will revisit them in Part 3 when we connect our matrix keyboard. In the meantime, before we actually connect the LCD to the 18X, we first need to cover the relevant basics of character-based LCDs.

Intelligent Character LCDs

A Liquid Crystal Display (LCD) can be an extremely useful module to include in many microcontroller projects. We will focus on character displays (rather than graphics displays) because they are readily available, relatively inexpensive, and easy to interface to a microcontroller. The discussion will be confined to alphanumeric LCDs based on the Hitachi HD44780 controller chip, which constitute the vast majority of the displays that are currently available from surplus and other electronic suppliers (see the Resources sidebar). These displays are commonly available in sizes of 8, 12, 16, 20, 24, 32, or 40 characters by one, two, or four lines.

All HD44780 LCDs share a common pin-out, which is presented in Figure 2, along with the corresponding PICAXE-18X connections. (Each connection is discussed in more detail below.) Pins 1-14 are always present, while pins 15 and 16 are only available on displays which include a backlight. Backlit displays, of course, are much more visible

18X Pin	LCD Pin	Symbol	Function
—	1	Vss	LCD Power Supply (Ground)
—	2	Vcc	LCD Power Supply (+3 to +5 volts)
—	3	Vee	Contrast Control (Analog) (Consult Data Sheet)
8	4	RS	Register Select Input (H=Data; L=Command)
—	5	R/W	Read/Write Input (H=Read; L=Write)
9	6	E	Enable Input
—	7	DB0	Data Bus I/O Bit 0 (Not used in four-bit mode)
—	8	DB1	Data Bus I/O Bit 1 (Not used in four-bit mode)
—	9	DB2	Data Bus I/O Bit 2 (Not used in four-bit mode)
—	10	DB3	Data Bus I/O Bit 3 (Not used in four-bit mode)
10	11	DB4	Data Bus I/O Bit 4
11	12	DB5	Data Bus I/O Bit 5
12	13	DB6	Data Bus I/O Bit 6
13	14	DB7	Data Bus I/O Bit 7
—	15	A	Optional Backlight Anode (Consult Data Sheet)
—	16	K	Optional Backlight Cathode (Consult Data Sheet)

FIGURE 2. PICAXE-18X to LCD interface pin-out.

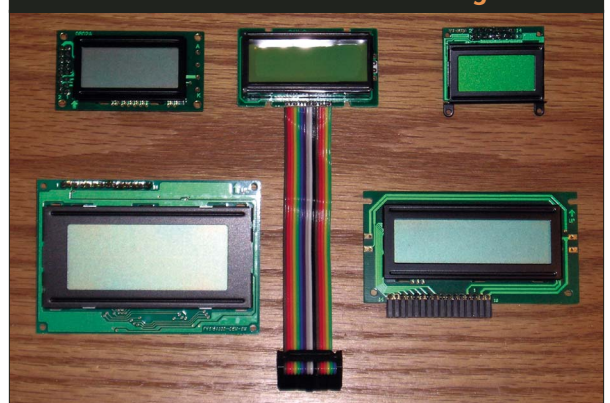
than non-backlit displays, but they are also considerably more expensive and consume a significantly greater amount of power, so they may not be suitable for battery-powered projects.

Actual pins are rarely included on the LCD board; usually there are one or two rows of holes into which you can solder your connector or cable of choice. While the 14 or 16 pin pin-out is standard, the actual physical arrangement of holes on the LCD board is not. The two most common configurations are one row of 14 or 16 holes or two rows of seven or eight holes, as shown in Figure 3. Also, the holes are sometimes at the top edge of the LCD board and sometimes at the bottom, or even the side. If you develop your projects on a breadboard, the single-row arrangement at the bottom edge

of the board is the easiest to use; you can solder a 14 or 16 pin straight male header to the LCD board and plug it directly into your breadboard (LCD “laying down”) or use a right-angle male header if you want the LCD to “stand up” on the breadboard.

Another option is to solder a right-angled female header onto the LCD board and plug it into a male header on the breadboard. This approach provides

FIGURE 3. LCD sizes and connector configurations.



Getting Started With PICAXE Microcontrollers

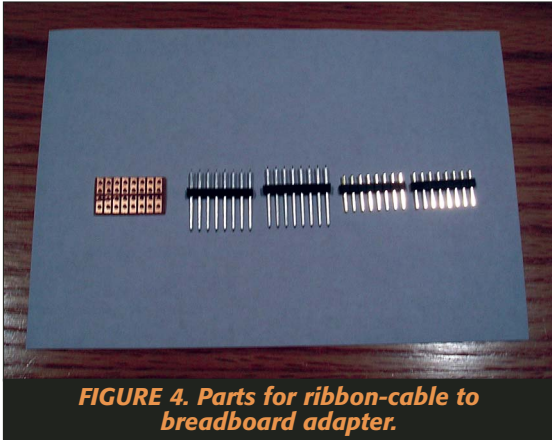


FIGURE 4. Parts for ribbon-cable to breadboard adapter.

the flexibility of changing the male header from straight (LCD laying down) to right-angled (LCD standing up).

The seven or eight hole by two-row configuration is somewhat more difficult to connect to a breadboard. One solution is to solder a 7x2 or an 8x2 straight male header to the LCD board and construct a short 16-pin ribbon cable with a 8x2 IDC connector on one end and a 16-pin .100 inch IDC DIP flat cable plug (Jameco part no. 42673CG) on the other. (The 16-pin IDC connector can be used with both the 14 and 16-pin headers, just be sure to note which two connections are *not* used.) If you choose this approach, you will need to find some way to support the LCD or just lay it on your bench — a nuisance to say the least!

Another approach is to solder a 7x2 or 8x2 straight male connector to the LCD board, construct a small adapter on a stripboard, and use it to plug the LCD into the breadboard,

either directly or by using a 16-pin ribbon cable. Figure 4 shows the parts necessary to construct an adapter for use with a ribbon cable and Figure 5 is a photo of all three adapters (top left: ribbon cable with DIP connector; top right: LCD connected directly to breadboard; bottom: ribbon cable to breadboard adapter). Details of the construction of all three types of adapters are presented on the author's

website at www.JRHackett.net

Interfacing PICAXE Chips with Character LCDs

Once you have selected an LCD and constructed the necessary hardware interface, you're ready to connect the LCD module to the PICAXE. All HD44780 LCDs can operate in one of two modes of data transfer: four-bit (nibble) mode or eight-bit (byte) mode. As you would expect, byte mode requires eight data line connections between the processor and the LCD, while nibble mode only needs four data line connections. Of course, it takes two nibbles to make a byte, so nibble mode is approximately twice as slow as byte mode. In spite of this speed difference, four-bit mode is fast enough and four I/O pins are very valuable on a small processor, so we will use nibble mode in this article. Readers who prefer speed at any price should consult their LCD

Data Sheet for byte mode interfacing.

The third section of the PICAXE manual, available from Revolution Education (www.reved.co.uk), is entitled "Microcontroller Interfacing Circuits" and contains a wealth of information on interfacing various input and output devices to PICAXE processors; pages 30 through 41 deal with LCD module interfacing.

Another valuable resource for information on PICAXE-LCD interfacing is www.hippy.freemove.co.uk/picaxelc.htm.

As discussed in the second link above, there is an error in the PICAXE documentation as to how the PICAXE-18X should be connected to the LCD. In two places in the PICAXE manual, it is stated that Output Pins 4 through 7 of the 18X should be connected to the LCD data pins 7 through 4 in order. However, as "the Happy Hippy" points out, this is actually the reverse of the correct connections; PICAXE Output Pins 4 through 7 should be connected to the LCD data pins 4 through 7 in order.

The connections required to interface the PICAXE-18X with an HD44780 LCD (introduced earlier in Figure 2) are fairly straightforward, but a couple of clarifications are in order:

- **Pin 3** (Display Contrast Adjust) can be connected to a potentiometer for complete control, but a 1K resistor from pin 3 to ground usually provides very acceptable contrast. If you prefer to use a pot, consult either of the references above for wiring details.

- **Pin 5** is the R/W (Read/Write Select). Since we will only be writing to the LCD display, we can connect the R/W line directly to ground.

- **Pin 6** (Enable) needs to be pulsed "high" briefly (e.g., 10 μ s) each time a data byte or command byte is transferred to the LCD.

- **Pins 15 and 16** are only present if the LCD is backlit. If it is, consult the data sheet for the display you are using for the correct connections, because there are variations here. For example, the LCD backlighting circuit may or may not include an internal current-limiting resistor. Care must be taken to correctly wire these pins.

PICAXE-18X to HD44780-based Character LCD Interface Circuit

Now that we have clarified the required LCD connections, we're ready

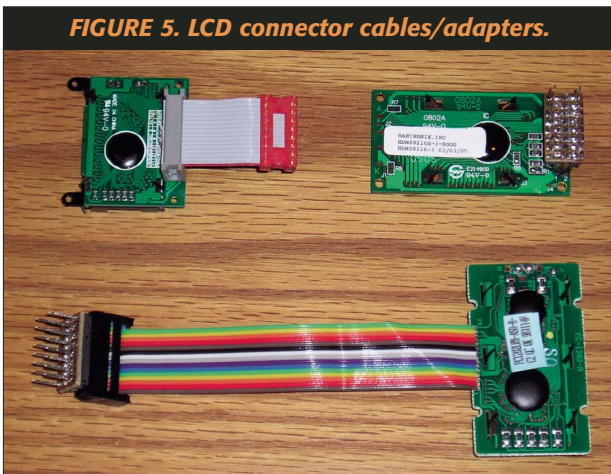


FIGURE 5. LCD connector cables/adapters.

to interface an LCD to the PICAXE-18X. I will be using a 20-character by four-line backlit LCD, but the same setup will work for any HD44780-based LCD. A quick eBay search for “HD44780 LCD” will find dozens of suitable displays.

Figure 6 presents the schematic of the circuit we will be using; Figure 7 is a photo of the breadboard setup with the LCD removed so that all the connections are visible. Figure 8 shows the completed breadboard setup, including the LCD. As you can see in Figure 8, the display I am using includes a connector along its top edge. Rather than finding some way to support the display to make it visible, I found it easier to support the entire breadboard at about a 60 degree angle – cutting a thin slot in a piece of scrap wood was all that was required.

As you can see in the schematic presented in Figure 6, all 5 of the unused PICAXE-18X inputs (pins 1 and 15-18) are tied to ground with a 10K resistor. In general, if unused inputs are left disconnected (“floating”) they can be affected by static electricity, which can result in excessive current drain and/or possible erratic operation of the circuit. Tying them to ground (or +5V) avoids these risks.

Of course, you can modify the wiring layout on the breadboard to suit your purposes, but if you plan to attach the matrix keyboard when we get to Part 3 of this article, make sure pins 10 through 18 on the PICAXE-18X are easily accessible because we will be using them to connect the keyboard.

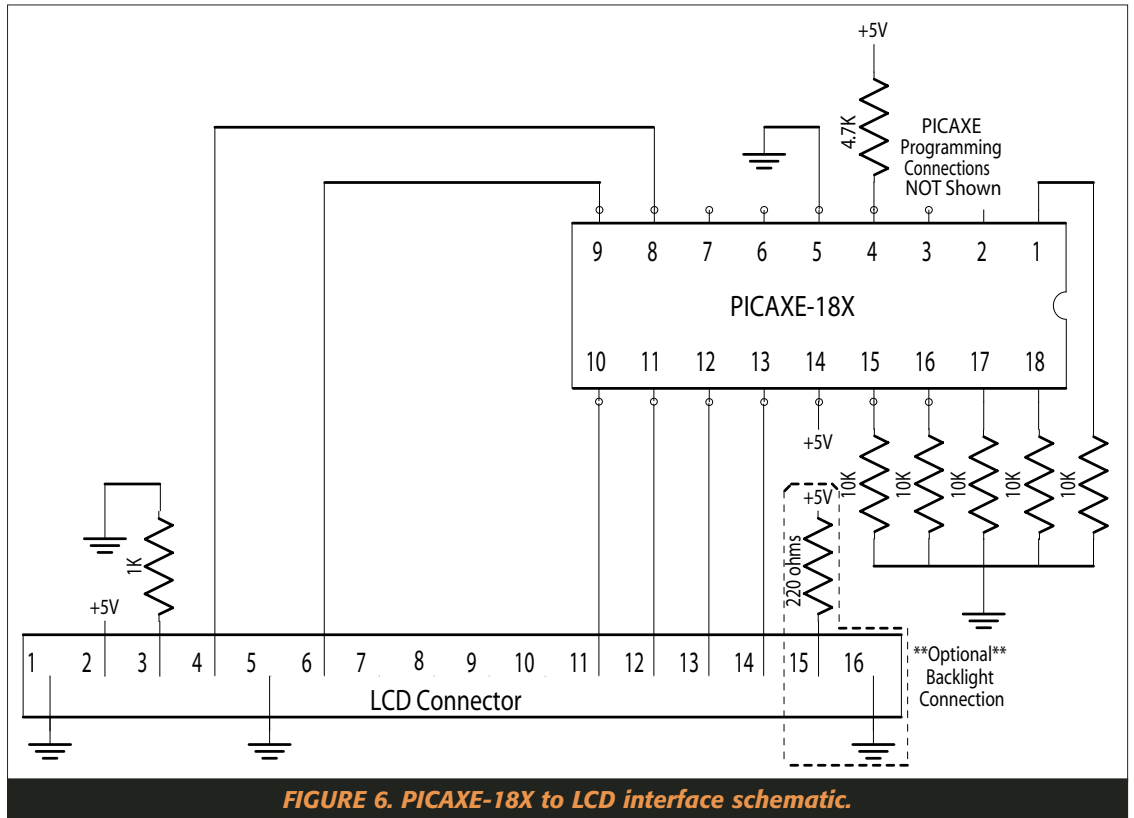


FIGURE 6. PICAXE-18X to LCD interface schematic.

LCD Instruction Set

All HD44780-based LCDs share a common set of instructions or commands to control their operation. For example, there are commands to implement either a four-bit or an eight-bit data interface, to use a blinking or underlined cursor, to print or scroll the display left to right or right to left, etc. A thorough explanation of the HD44780 instruction set is beyond the scope of this article; refer to your LCD’s data sheet for a complete listing or do a Google search for the words

“HD44780” and “LCD” – there is a huge amount of information on the web. An excellent two-part article on the subject can be downloaded at www.epemag.com/lcd1.pdf and www.epemag.com/lcd2.pdf.

At this point, we will be using only the following **LCD Commands**:

- **1** – Clear display and move cursor to Home position
- **12** – Hide cursor
- **14** – Turn on LCD and cursor
- **32** – Set LCD to four-bit operating mode

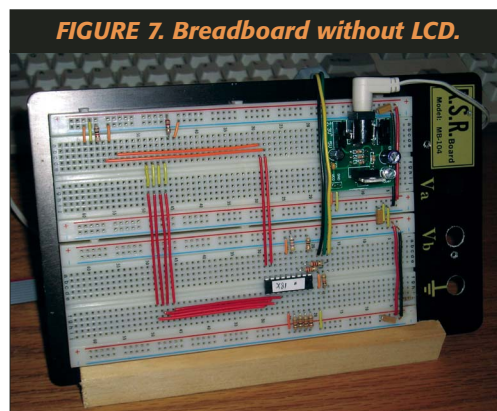


FIGURE 7. Breadboard without LCD.

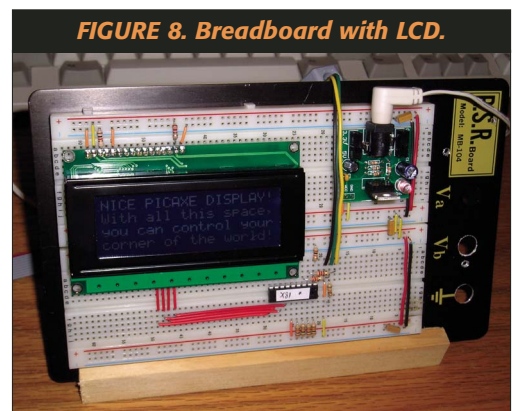


FIGURE 8. Breadboard with LCD.

Getting Started With PICAXE Microcontrollers

FIGURE 9. "Hello20X4LCD" Program Listing.

```
' **** LCD20x4.bas ****
'
'   This program runs on a PICAXE-18X @ 4 MHz.
'   It interfaces with an HD44780-based 20x4 LCD display.
'
' ****
*****

' **** Constant Definitions ****

      symbol      En = 3      ' LCD Enable pin connected to PICAXE output 3
      symbol      RS = 2      ' LCD RegSel pin connected to PICAXE output 2

' **** Variable Definitions ****

      symbol      char = b1    ' character to be sent to LCD
      symbol      index = b2   ' used as counter in For-Next loops

' **** Data Definitions ****

      data 0, ("NICE PICAXE DISPLAY!")    ' LCD row 1 stored in EEPROM memory
      data 40, ("With all this space,")    ' LCD row 3 stored in EEPROM memory
      data 20, ("you can control your")    ' LCD row 2 stored in EEPROM memory
      data 60, ("corner of the world!")    ' LCD row 4 stored in EEPROM memory

' **** Main Program ****
main:  gosub init                      ' initialize LCD

      for index = 0 to 39              ' output data to 1st (& 3rd!) row of LCD
        read index, char              ' read character from EEPROM
        gosub wrchr                    ' send character to LCD
      next index

      char = 192                      ' instruction: start of 2nd row of LCD
      gosub wrins                      ' send instruction to LCD

      for index = 40 to 79             ' output data to 2nd (& 4th!) row of LCD
        read index, char              ' read character from EEPROM
        gosub wrchr                    ' send character to LCD
      next index

      end

' **** End Main Program - Subroutines Follow ****

' **** Subroutine init ****

init:  pins = 0                      ' clear all PICAXE output lines
      pause 200                     ' pause 200 ms for LCD initialization

      pins = 48                     ' instruction: set to 8-bit operation
      pulsout En,1                   ' send data to LCD
      pulsout En,1                   ' send data (necessary)

      pins = 32                     ' instruction: set to 4-bit operation
      pulsout En,1                   ' send data to LCD
      pulsout En,1                   ' send again (necessary in 4-bit mode)

      pins = 128                     ' instruction: set to 2 line operation
      pulsout En,1                   ' send data to LCD
```

- **48** — Set LCD to eight-bit operating mode
- **128** — Move cursor to start of first line
- **192** — Move cursor to start of second line

LCD Character Addressing

Until now, everything we have covered about HD44780-based LCDs has been very consistent regardless of the size of the display. However, now we need to discuss how a character is placed at a specific location or “address” on the display and, at this point, it can get a little confusing. First of all — except for the smallest display (eight characters by one line) — all HD44780 displays are organized into two “lines.” So, what we think of as a 16x1 line display is actually an 8x2 line display with the second line beginning in the middle of the only line — go figure! Also, a 20x4 display — such as the one used in this article — is actually a 40 character by two line display. To make matters worse, the two lines are interleaved: Line 1 begins where you would expect (first position of the first row), but when row 1 of the display is filled, the line continues at the beginning of row 3! Similarly, line 2 starts at the beginning of row 2 of the display and jumps to row 4.

If that isn’t confusing enough, it turns out that just about all of these displays have data storage of two lines by 40 characters. In other words, except for a 20x4 display, all the smaller LCDs can store more data than they can display at one time, which explains why data can be scrolled on these displays. I chose the 20x4 display before I was aware of all these intricacies, but it actually turns out to be easier to use than the smaller ones, because there is no hidden data stored in the display. The only complication is the interleaving of lines 1 and 2, but this is easy to handle, as we are about to discover.

When you need to figure out

the character addressing scheme for a specific display, it's extremely helpful to have access to the display's data sheet, but if that isn't possible, you can try the "Let's see what happens!" approach of the "Hello20x4LCD" program presented in Figure 9. Essentially, what the program does is write four 20-character strings to the LCD so we can see where they are positioned on the display. However, before you read through or try the program, there are a couple of points that may need clarification.

First, PICAXE Basic does not support string variables, but all PICAXE chips have built-in EEPROM Data Memory (256 bytes in the PICAXE-18X), so the simplest approach to outputting data to an LCD is to first store it in Data Memory and then transfer it byte-by-byte to the LCD for display. If you look at the four Data Memory assignments in the program listing of Figure 9, you can see how the interleaving of the LCD lines 1 and 2 has been managed. The starting addresses for the second and third 20-character string have been reversed to "undo" the interleaving — look at the resulting output presented in Figure 8 to see the results of the reversal.

Secondly, for some reason (which I have been unable to ascertain), when a four-bit data interface is used with an HD44780-based display, the initialization commands need to be sent to the LCD twice — so what seems like redundancy in the initialization subroutine code is actually necessary.

Finally, aside from placing the cursor at the beginning of line 1 or line 2, it isn't necessary to update the address for each character to be displayed — the LCD handles that automatically. In fact, because a 20x4 LCD displays every character its memory can store, it isn't even necessary to position the cursor at the beginning of line 2. One for-next loop with 80 iterations will also work, as long as your initial Data Memory assignments take the interleaving of the two lines into account. However, this is not true for all the smaller LCDs, which cannot display the full 80 characters, so the program is written with those displays in mind, as well.

Figure 9 continued ...

```
char = 14                                ' instruction: screen on, cursor on
gosub wrins                               ' send instruction to LCD

char = 1                                  ' instruction: clear display, cursor home
gosub wrins                               ' send instruction to LCD

char = 12                                  ' instruction: hide cursor
gosub wrins                               ' send instruction to LCD

return

' **** Subroutine wrchr ****
wrchr: pins = char & 240                   ' place high nibble of char onto pins
      high RS                             ' make sure RS is high
      pulsout En,1                         ' send data to LCD

      pins = char * 16                     ' place low nibble of char onto pins
      high RS                             ' make sure RS is high
      pulsout En,1                         ' send data to LCD

      return

' **** Subroutine wrins ****
wrins: pins = char & 240                   ' place high nibble of char onto pins
      pulsout En,1                         ' send data to LCD

      pins = char * 16                     ' place low nibble of char onto pins
      pulsout En,1                         ' send data to LCD

      return
```

Conclusion

In the final part of this series, we will add a 12 or 16 key matrix keyboard and a piezo beeper to our hardware design and develop the software necessary to implement a simple stand-alone I/O terminal for other microcontroller-based projects. Of course, a second microcontroller will be necessary to fully test the functionality of the terminal. Any processor capable of sending and receiving five-volt level serial data at 1200, 2400, or 4800 baud will do. If you don't have one on hand, the PICAXE-08M is an excellent candidate. It has the same Basic programming system as the 18X, is amazingly small (eight pins), and costs less than \$4 (see the Resources sidebar). In the meantime, you might experiment with placing text at specific locations on your LCD display to gain experience with its specific addressing scheme. See you next time! **NV**

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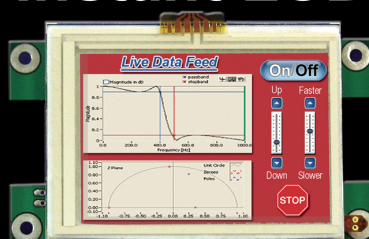
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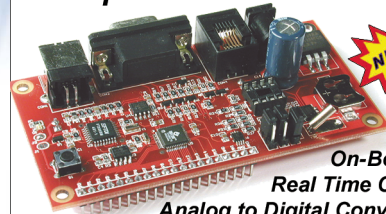
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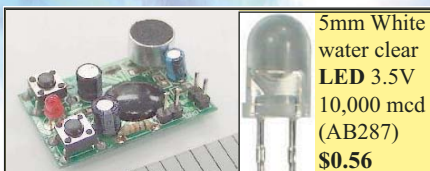
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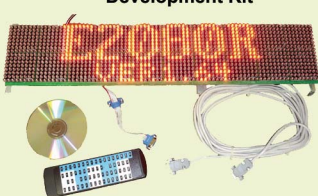
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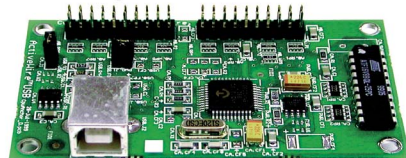
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The circuits, and information about the winners and other applicants can be found at **www.schmartdeveloper.org**. The winners of the contest are:

- Robert Gatt — Port Fairy, Australia — Nokia 5110 LCD Interface
- Sunil Jha — Kanpur, India — Seven-Segment Display Module
- Indranil Majumdar — Kolkata, India — 3.6VDC Li Charger
- Jack Atkinson Jr. — Grant, AL USA — 8032 Microcontroller Module
- Jared Bayne — Mission, KS USA — Robot Controller
- Mike Otte — Pearl City, IL USA — Finger Talker
- Russell Pead — Worcester, MA USA — TTL Test Board Module
- Jerry Rutherford — Overland, KS USA — Mega 8 Module

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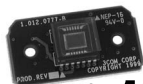
In digital imaging and photography Charge Coupled Devices (CCDs) capture light on their surfaces which is converted into images. These CCDs are, in effect, digital cameras without lenses. We have two types, both made by Sharp Electronics. We don't have documentation, but both are new and should be functional.

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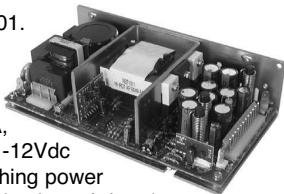


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Access Flash Drives with a Microcontroller

— by Jan Axelson

USB Flash drives provide a handy way to store any type of information in a small package. The drives – also known as thumb drives and USB keys – seem ideal for use in data loggers and other microcontroller-based projects. But to access files in a Flash drive, a microcontroller must have USB host hardware and support for a file system. Microcontroller-based devices often lack these elements.

To the rescue is the USBwiz chip from GHI Electronics. With the USBwiz, just about any microcontroller can read and write to files in Flash drives. The microcontroller can access the USBwiz via an asynchronous serial (UART) port or an SPI or I²C port. Most microcontrollers support one or more of these ports. The USBwiz can also access USB hard drives and Flash-memory cards such as MultimediaCards (MMCs) and Secure Digital (SD) Cards.

In this article, I'll show how to use the USBwiz to create a file in a Flash drive, write to the file, and read the file's contents. I'll also show how to control the USBwiz from a PC using a terminal utility or Visual Basic. When you have working code on the PC, you can port the code to your microcontroller of choice.

About Flash Drives and USB

A USB Flash drive (Figure 1) is a USB device that contains Flash memory that PCs and other USB hosts can access in the same way as other drives. If you attach a Flash drive to a

USB port on a PC, Windows assigns a drive letter and shows the drive in My Computer.

Current Flash drives have capacities as large as eight gigabytes, which is more than enough for the data a small system might need to store and access.

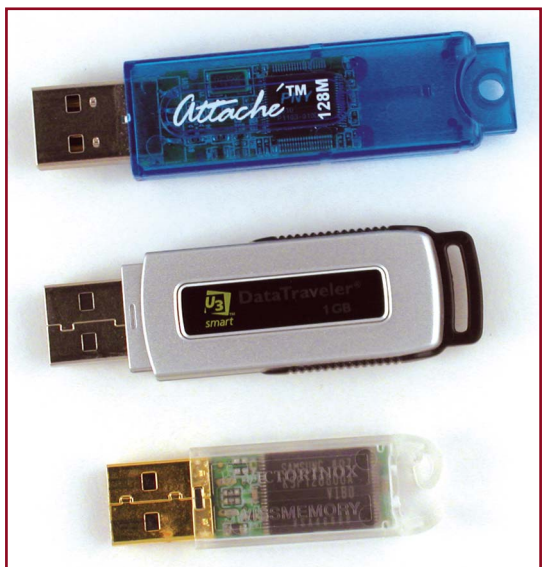
Every USB communication is between a host and a device. The host contains host-controller hardware and manages communications on the bus. The device contains device-controller hardware and responds to communications from the host. Host hardware and code are more complex than device hardware and code.

PCs contain host controllers and thus can communicate with USB devices, including Flash drives. Most microcontrollers with USB support contain device controllers. A microcontroller that wants to access Flash drives or other USB devices must have a host controller embedded in the microcontroller or accessed on a separate chip. This is where

the USBwiz comes in.

Inside the USBwiz

The USBwiz is a programmed Philips LPC2141 microcontroller based on a 16/32-bit ARM processor core. For USB communications, the chip interfaces to a Philips ISP1160 USB host controller. The USBwiz-OEM board (Figure 2) contains both chips, two USB connectors, a connector for an SD Card or MultiMediaCard, and a user



■ **FIGURE 1.** USB Flash drives are handy for storing information for just about any purpose.

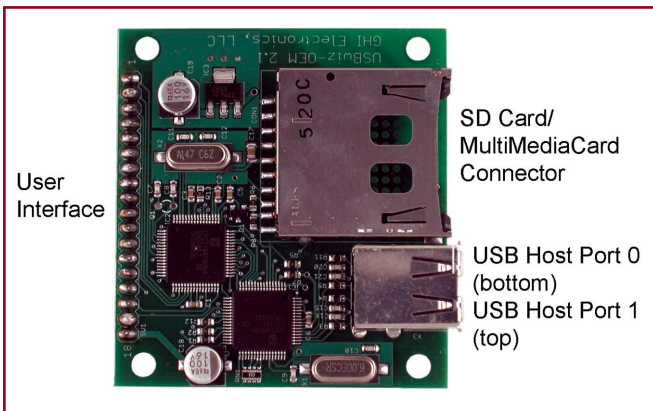


FIGURE 2. With the USBwiz-OEM board, microcontrollers can access Flash drives and other USB devices, as well as SD Cards and MultiMediaCards.

interface that brings out connections for powering and communicating with the circuits. The user interface is a line of holes that accepts an 18-pin SIP header (which you provide). You can plug the header into a breadboard or mating receptacle or solder the header directly to a circuit board.

GHI Electronics provides free USBwiz firmware that supports a command set for communicating with the board. All commands and responses are ASCII text. A boot-loader program loads the firmware

FIGURE 3. To experiment with the USBwiz, connect it to a PC. A DLP-USB232M converts between the UART port on the USBwiz and a PC's USB port.

into the USBwiz from an SD Card or MultiMediaCard.

This article focuses on communications with USB drives. The USBwiz can also talk with USB mice, some printers, some modems/cell phones, and USB device controllers from FTDI Chip.

A Setup for Experimenting

The USBwiz is ideal for microcontroller communications, but sometimes the easiest way to check out a new device is to hook it up to a PC and use its resources to run and debug code. When you have everything working, you can port the code to your microcontroller of choice.

Figure 3 is a circuit that connects a USBwiz-OEM board to a PC using the USBwiz's UART port. To interface the port to a USB port on a PC, I used a DLP Designs DLP-USB232M USB Adapter Board, which comes in a handy dual in-line package (DIP). You can build Figure 3's circuit on a breadboard.

If your PC has an RS-232 serial port or a USB/RS-232 adapter, you

can replace the DLP-USB232M with a Maxim Semiconductor MAX233 or similar chip that converts between asynchronous, serial and RS-232 voltages.

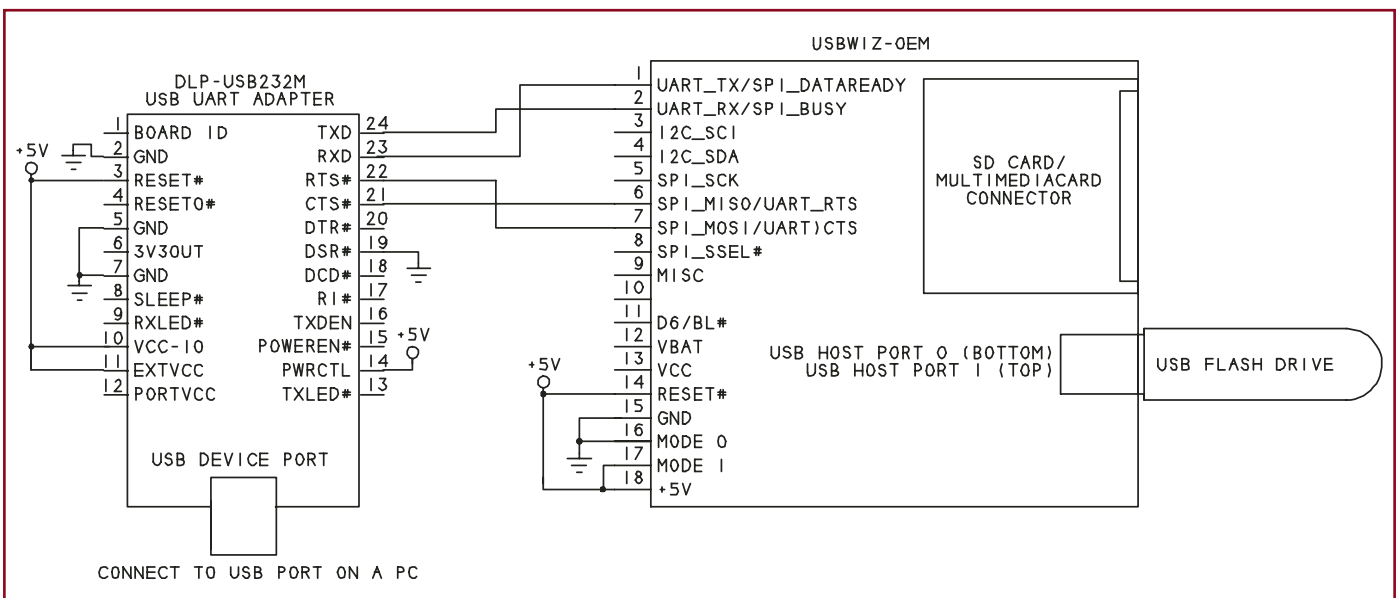
With the circuit connected to a PC, you can use a terminal utility or just about any programming language to communicate with the USBwiz via a COM port.

USBwiz Communications

Every USBwiz command must be followed by a CR code (ASCII 0Dh). After receiving a command and CR, the USBwiz returns a status code followed by a CR. A code of "100" indicates success. For some commands, the USBwiz follows the status code with additional information, or the sender of the command sends additional information as described below.

Windows includes a terminal utility called Hyperterminal, but I don't recommend using it with the USBwiz. To view what you're typing and the responses, you want the terminal's display to add a line feed (LF) to each CR sent and received without sending LFs to the USBwiz. I couldn't find a combination of settings that would do this in Hyperterminal.

Instead I used the free TeraTerm Pro (see Sources for a link). In



TeraTerm Pro, under Setup > Serial Port, set Port to the COM port your device uses and set Baud rate = 9600, Data = 8 bit, Parity = none, Stop = 1 bit, and Flow control = none. If the port uses a USB/serial adapter, the adapter will need to be attached before TeraTerm will list it. Under Setup > Terminal, set New-line Receive to CR+LF and New-line Transmit to CR. Check the Local echo checkbox. You're now ready to start sending commands to the USBwiz (Figure 4).

If you have another favorite terminal utility, you can probably use it by setting the options as described above.

I'll show some of the essential commands for accessing files on Flash drives. The USBwiz's User Manual documents many more commands, including commands that access other device types.

The Commands

Before reading and writing to files on a Flash drive, the USBwiz must receive and execute four commands.

USB hosts learn about attached devices by sending a series of requests in a process called enumeration. The device returns a series of data structures called descriptors, which describe the device's functions and capabilities. A Flash drive sends descriptors that tell the host that the device belongs to USB's mass-storage class. The host then knows it can use mass-storage protocols to communicate with the device.

The UI command causes the USBwiz to enumerate an attached USB Device:

UI $p > h$

where p is the port number and h is the device handle to assign to the device.

The USBwiz-OEM board has two USB connectors: Port 0 on the bottom and Port 1 on top. This command enumerates the device on Port 0 and assigns device handle 0:

$$UI \quad 0 > 0$$

■ **FIGURE 4.** The USBwiz communicates via text commands.

The `UM` command registers an enumerated USB mass-storage device and assigns a mass-storage handle for communicating with the device:

UM h>m

where h is the assigned device handle and m is the mass-storage device handle to assign to the device.

This command assigns mass-storage handle 0 to the device with device handle 0:

UM $0 > 0$

After executing the UM command and returning a status code of !00, the USBwiz returns "\$" followed by the number of the highest logical unit (LUN) in the media:

\$00

On a PC, each LUN corresponds to a drive letter. Partitioned drives have multiple LUNs. Flash drives typically have just one LUN, numbered zero.

The AM command prepares the USBwiz to communicate with a mass-storage device and checks to ensure the storage media is available:

$$AM \quad U_{m < n}$$

where m is an assigned mass-storage handle and n is the LUN.

This command prepares to communicate with LUN 0 in the device with mass-storage handle 0:

AM $U_0 < 0$

Note that this command uses "<" rather than ">".

To read and write to a file, the USBwiz must mount a file system to the device. The MU command mounts a file system to a mass-storage device:

MU m>Un

where m is the file system and n is the



mass-storage handle of a USB device. The USBwiz supports up to three independent file systems.

This command mounts file system 0 on the USB device with mass-storage handle 0:

MU 0>U0

If the USBwiz returns !00 in response to each of the above commands, you're ready to read and write to files.

Accessing Files

Before you can write to a file, you need to open it. The `OF` command opens a file:

OF nM>filename

where `n` is a file handle, `filename` is the name of the file, and `M` is the read or write mode. Set `M` to `"W"` to overwrite any existing file of the same name, `"A"` to append to an existing file, or `"R"` to read from the file.

This command opens the file "test.txt" for overwriting using file handle 0:

OF 0W>test.txt

If the file doesn't exist, the USBwiz creates it.

The WF command writes to an open file:

```
WF n>ssssssss
```

where n is the file handle and ssssssss is the amount of data to write expressed in ASCII hex. (ASCII hex means the value is hexadecimal and expressed as text using the characters 0-9 and A-F.)

This command writes 13 (0Dh) bytes to the file opened with file handle 0:

```
WF 0>D
```

On receiving a valid WF command, the USBwiz returns !00, waits to receive the specified number of bytes, and returns "\$" followed by the number of bytes written and !00:

```
!00
Nuts & Volts
$0000000D
!00
```

(The text "Nuts & Volts" followed by a CR is 13 bytes.)

The CF command closes an open file and frees the file handle:

```
CF n
```

where n is the handle.

This command closes file handle 0:

```
CF 0
```

This command opens the file test.txt for reading:

```
OF 0R>test.txt
```

Using Visual Basic to Access the USBwiz

You can also write applications to communicate with the USBwiz. Microsoft's .NET Framework 2.0 includes a SerialPort class for accessing hardware that uses a COM-port interface. This includes devices connected to USB/serial converters such as the DLP-USB232M module. You can run the following Visual Basic code using the free Visual Basic 2005 Express edition available from Microsoft.

Configuring the COM Port

This statement defines SelectedPort as a member of the SerialPort class:

```
Friend SelectedPort As System.IO.Ports.SerialPort
```

These statements set port parameters and open a COM port in Visual Basic .NET:

```
selectedPort = My.Computer.Ports.OpenSerialPort(
    "COM4", 9600, Parity.None, 8, StopBits.One)
selectedPort.Handshake = Handshake.RequestToSend
selectedPort.ReadTimeout = 1000
selectedPort.WriteTimeout = 1000
```

The NewLine property defines what is considered the end of a line for the ReadLine and WriteLine methods. Because the USBwiz uses a carriage return only, NewLine should be set to the Visual-Basic constant vbCr:

```
selectedPort.NewLine = vbCr
```

Accessing Files

The WriteLine and ReadLine methods send data to the port and read data received on the port. WriteLine adds a NewLine character to the end of the data being sent. ReadLine returns all received data up to a NewLine character and discards the NewLine character.

This statement writes a UI command and CR to a serial port:

```
SelectedPort.WriteLine("UI 0>0")
```

The ReadLine method can read a response code returned by the USBwiz:

```
Dim response As String = ""
response = SelectedPort.ReadLine
```

This statement requests to open the file "test.txt" using file handle 0 for writing:

```
selectedPort.WriteLine("OF 0W>test.txt")
```

This statement requests to write three bytes to the opened file with file handle 0:

```
selectedPort.WriteLine("WF 0>3")
```

After sending this command and receiving a response of "00!", the application should send the bytes to write to the file without adding a CR code to the end (unless desired). The Write method does the job:

```
Dim bytesToSend as byte()
bytesToSend(0) = 78 ' ASCII "N"
bytesToSend(1) = 38 ' ASCII "&"
bytesToSend(2) = 86 ' ASCII "V"
selectedPort.Write(bytesToSend, 0,
    bytesToSend.GetLength(0))
```

This statement requests to read three bytes from the open file with file handle 0 and filler character "X":

```
selectedPort.Read("RF 0X>3")
```

After returning a response code, the USBwiz returns the requested data. The Read method reads the data:

```
Dim bytesRead As Integer
Dim bytesToRead as Integer
Dim receiveBuffer() As Byte
bytesToRead = 3
ReDim receiveBuffer(bytesToRead - 1)
bytesRead = selectedPort.Read(receiveBuffer, 0,
    bytesToRead)
```


The RF command reads from a file:

```
RF nM>ssssssss
```

where n is a previously obtained file handle, M is a filler character, and sssssss is the number of bytes to read expressed as ASCII hex. If the requested number of bytes aren't available, the USBwiz inserts the filler character for the missing bytes.

This command requests to read 15 (0Fh) bytes from a file opened with file handle 0 using "X" as the filler character:

```
RF 0X>0000000F
```

On receiving a valid RF command, the USBwiz returns !00 followed by the requested data, filler characters if needed, "\$", the number of bytes read, and !00:

```
RF 0X>F
!00
Nuts & Volts
XX$0000000D
!00
```

In the example that's shown above, the command requested two more bytes than the file contained, so the file's contents were followed by two filler characters.

The sidebar *Using Visual Basic*

to Access the USBwiz shows how you can perform similar functions from a Visual-Basic application. For a complete Visual Basic application that accesses the USBwiz, visit my website at www.Lvr.com. Another option to give your programming a quick start is the free Microchip C library for the USBwiz available from GHI Electronics. **NV**

About the Author

■ Jan Axelson is the author of *USB Complete*, *USB Mass Storage Complete*, and *Serial Port Complete*. For USBwiz code and more information about accessing Flash drives and designing USB devices and hosts, visit Jan's website at www.Lvr.com.

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Sources

■ **DLP Designs** – DLP-USB232M USB Adapter Board
www.dlpdesign.com

■ **GHI Electronics** – USBwiz
www.ghielectronics.com

■ **Microsoft Visual Basic 2005 Express**
<http://msdn.microsoft.com/vstudio/express/vb/>

■ **TeraTerm Pro**
<http://hp.vector.co.jp/authors/VA002416/teraterm.html>

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DISPLAYS for ALL OCCASIONS

by Faiz Rahman

If a picture is worth a thousand words, then moving pictures are surely worth many thousands of words. It is this great descriptive power of moving imagery that has made televisions so popular.

Televisions were introduced in the late 1930s and rapidly replaced radio sets as the prime entertainment appliance for the home. In most of the intervening years, the only notable development had been the appearance of color TVs in the 1950s. For the past few years, however, there have been several new developments in television technology. The most visible of these are the emergence of new displays which are spoiling us for choice in the marketplace.

In this article, we will look at a number of the most prominent display technologies that are available on the market. These include Plasma Display Panels (PDPs), Liquid Crystal Displays (LCDs), Digital Light Projection (DLP), and Electronic Ink Displays (EIDs). The last one is still under development and is targeted at semi-static applications such as changeable signage.

Televisions, of course, are not the only devices that incorporate displays. A wide variety of handheld gadgets, outdoor information signs, computers, and even movie theaters require means for displaying stationary and moving images. Advances in display technologies have far reaching consequences because they touch almost every aspect of modern life. For this reason, it is important that we understand the basic technical features behind the new generation of display technologies. If nothing else, this will help us make informed choices as consumers of display equipment.

Plasma Displays

Few display technologies have had such an impact on consumer sentiments as flat panel plasma displays. In recent years, their outstanding visual appeal has rejuvenated a languishing TV market. Plasma displays are actually quite old, having been invented in the 1960s by Donald Bitzer and Gene Slottow at the University of Illinois. They developed a prototype monochrome

display for use as computer monitors.

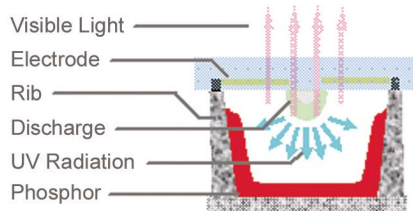
This initial device was basically an array of neon-filled cells that could be selectively excited by an AC voltage. Making large dot matrix displays from the Nixie tubes of the 1950s and 1960s was a revolutionary idea. A few years later, a license was purchased by IBM who developed it further into the 3290 Information Panel that came out in 1983. In the years that followed, several Japanese companies also became interested in this display technology, and with the backing of the Japanese national broadcaster NHK, began to aggressively develop it for TV applications.

As a result of subsequent efforts in the United States and Japan, these displays changed from monochrome to color and thus gradually evolved from high-tech neon signs to dense arrays of fluorescent lights.

Structurally, plasma display panels consist of an array of gas discharge cells like the one shown in Figure 1. An entire panel is made from a honeycomb-like sheet of millions of such chambers. These cells are filled with a mixture of inert gases, such as krypton and xenon, at low pressure. Applying a high voltage across such a cell ionizes the gas mixture and causes it to emit ultraviolet radiation. While ultraviolet itself is invisible, it can be efficiently converted to visible light with the help of luminescent materials called phosphors. Actually, each pixel is composed of three sub-pixels: one each for red, green, and blue colors.

The phosphors used with these

FIGURE 1. A PDP cell, showing the placement of discharge electrodes, phosphor, and cell rib.



sub-pixels are the same as those in use with color CRT displays. Plasma technology has benefited from the years of phosphor developments that have made conventional color TVs so good at accurate color reproduction. Because each sub-pixel can be individually controlled over a wide range of output light intensity, by appropriately mixing light from the three pixel group, an amazingly large palette of colors could be displayed. The segmented design of plasma pixels, combined with a bubble-like design that shields individual pixels from neighboring pixels, further helps create very accurate color reproductions. The first generation displays had high-voltage electrodes placed in front of and at the back of each discharge cell, but these quickly gave way to a design where both high-voltage electrodes are placed at the front plane, and coplanar-electrode PDP cell design is now almost universal.

In contrast to the opposing-electrode design, this structure minimizes energetic ion bombardment of phosphors and thus prolongs phosphor life. A thin layer of magnesium oxide protects the inner cell surface from energetic particles created in the discharge plasma. As each pixel is itself a source of light, plasma panels don't need backlighting (as is the case with LCD panels). This makes them especially bright no matter what the panel size. The resulting rich, bright, and vibrant imagery provides for an extraordinary viewing experience.

Plasma Progress

Progress in the further development of plasma panels has been rapid. The first ever commercial plasma display TV was introduced by Pioneer in 1997. Last year, Japanese manufacturers displayed sets with screen sizes up to 103 inches across at the Consumer Electronics Show in Las Vegas, NV, and this year will bring even larger units.

Fujitsu and Hitachi are the leading producers of plasma display panels in Japan and they supply their panels to a number of other Japanese and European companies. Due to their low weight and naturally planar construction, plasma displays are the technology of choice for large and extra-large screen TVs and computer monitors.

The advent of High Definition (HD) TV technology has found a compatible partner in plasma display screens as their combination works exceedingly well for delivering and displaying images of outstanding clarity. No wonder most plasma TVs are now sold with built-in HDTV capability. Their large sizes, coupled with the ability to view them from virtually any angle, has also made plasma screens the favorite for electronic billboards and other outdoor display applications.

LCD Panels

Liquid Crystal Display (LCD) panels have been aggressively competing with plasma panels with several leading manufacturers offering both varieties. Compared to plasma displays, liquid crystal panels have better contrast and lower power consumption, which explains their widespread use in handheld and portable equipment. On a shop floor, these two might appear very much alike. However, closer inspection reveals interesting differences that originate from their very different technologies.

Unlike plasma panels, LCD panels are not self-emissive but rely on a set of discharge lamps or LEDs to provide screen illumination. The technology is the same as that used in laptop computer displays with the screen comprised of a large array of LCD cells that rely on switching polarized light to generate various light intensities.

A liquid crystal screen is made of a layer of special, highly-oriented molecular material (called liquid crystal) sandwiched between two sheets of thin, highly-polished float glass. These glass panes have a pattern of transparent electrodes printed on them that define individual pixels. There are also sheets of light-polarizing material that cover the whole assembly both at the top and on the bottom. The entire multilayer is illuminated with a flat backlight from the rear.

This arrangement is best understood by looking at a small cross-section of an LCD display, shown in Figure 2. Just as with plasma screens, each LCD pixel is also divided into

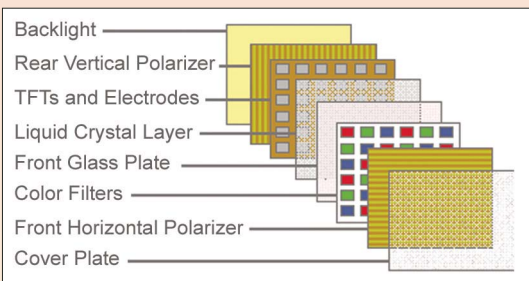


FIGURE 2. A section of an LCD panel, showing the arrangement of various layers.

three sub-pixels for red, green, and blue colors. Instead of phosphors, however, these displays use colored filters to define their sub-pixels. Polarized light — unlike ordinary light — has a well-defined directional character with its electric field oscillations all confined to only one direction that is at right angles to the direction in which the light is travelling. Such light can only pass through a polarizing material if the latter's polarizing orientation is the same as the polarized light's preferred direction of oscillation.

LCD cells can switch light by rotating the direction of the polarization of light passing through them. An applied cell voltage can alter the direction of orientation or twist the liquid crystal molecules which, in turn, changes the polarizing direction of the light passing through it. If this direction is the same as that defined by the polarizing material, then the light gets through the LCD assembly. Otherwise, it gets blocked.

With a mosaic of red, green, and blue filtered sub-pixels, color can also be displayed. The cell switching action is controlled by individual Thin Film Transistors (TFTs) that are integrated at the back of the lower glass pane. This close integration brings the benefits of high-speed, transistor-controlled switching to these so-called active matrix TFT LCDs and enables them to display television images.

Because polarization is orientation-dependent, LCDs do suffer from limited angular coverage. Recent advances have led to significant improvements in this area, however. Furthermore, reliability issues connected with the integration of large arrays of TFTs means that the manufacture of large liquid crystal panels becomes quite tricky and, for this reason, LCD-

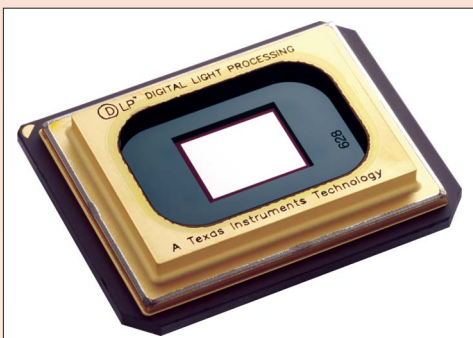


FIGURE 3. A packaged DLP chip from Texas Instruments.

based TVs are currently not available in quite as large screen sizes as PDP-based units. Continued progress in the development of very high brightness LED-based backlights and more controlled TFT process technologies will lead to larger LCD panels in the future.

Digital Light Projection

Unlike plasma and liquid crystal displays, Digital Light Projection (DLP) technology forms images by projecting a pattern of light and dark areas on a translucent screen. The projector is a specialized semiconductor chip that carries an array of tiny movable mirrors on its top surface. This Micro Electro-Mechanical System (MEMS) device is a true marvel of modern engineering in that it can digitally switch an image mosaic accurately and at very high

speeds. The DLP device is capable of steering light from a lamp source to a viewing screen, creating images of outstanding sharpness and vibrancy.

Invented by Larry Hornbeck of Texas Instruments (TI) in 1987, the DLP chip – which goes by the name of Digital Micromirror Device (DMD), combines both video processing and light switching functions on a two tier platform (see Figure 3 for what a typical packaged chip looks like).

The MEMS mirror assembly is a two-dimensional array of hinged mirror flaps and piezoelectric actuators that sit atop a CMOS under-layer that contains processing and drive circuitry. The entire chip is the same size as other commercial large size chips (about 1.5" x 1.5"). A complete projection system is somewhat complicated as it has to include such elements as a light source, filter wheel, and various mirrors and lenses. The projection assembly works by directing light from a powerful lamp, through a red-green-blue filter wheel, on to a DLP chip. The DMD mirror array then selectively projects a pixel pattern, through a projection lens, on to a screen. Red, green, and blue partial images are thus projected in quick succession as the filter wheel rotates. The three primary color images get blended together and one sees a composite full-color image. The display screen itself could be integrated with the rest of the system in a short distance projection configuration for producing domestic DLP televisions or it could be a remote screen as in movie theaters. In the latter case, of course, especially powerful lamps have to be used in order to provide sufficient light for wide screen illumination.

A Rise in DLP Usage

Several consumer electronics companies are now offering DLP televisions and these are rapidly replacing traditional CRT-based sets on account of their much superior resolution and color saturation properties. The high intensity tungsten-halogen lamps in these sets have a limited lifetime of 5,000 to 10,000 hours of continuous operation. These are somewhat expensive but not too difficult to replace. Needless to say, all digital projection systems currently

rely on Texas Instruments' DLP chips, as no other company has developed any alternative to this technology. The rest of the projection system is built by major manufacturers and purchased by smaller companies. The much touted digital projection cinema is also being enabled by DLP technology. As digital cine-print distribution and security issues are resolved, we will see a steeper rise in digital projection-equipped theaters around the world. As opposed to conventional film projection, digital distribution and projection offers many benefits such as low cost of print duplication, fast worldwide distribution, and multiple screenings with the same digital copy. In addition, 3D movies in the IMAX format, projected with twin projectors, are particularly suited to digital projection techniques and these might make a big comeback with the advent of mainstream digital projection cinemas. A digital cine projector from Barco is shown in Figure 4. Such projectors are commercially available now and are set to claim a bigger share of the market as digital projection gains further ground.

E-ink Technology

Yet another technology that is under rapid development is the so-called electronic ink or E-ink that offers extremely low power consumption and is suitable for semi-static display applications such as information update panels, clocks, and books. Sony Corporation has already introduced an E-book called Libre that uses E-ink technology developed by E-ink and Toppan Corporations. Electronics manufacturers in Europe are also eyeing this development for producing roadside signage and public information display systems. Even more products are expected in the next few years.

What is E-ink Made Of?

E-ink consists of millions of micro-capsules, each filled with two types of pigments, suspended in a clear fluid. One pigment is white in color and carries a permanent positive charge while the other is black in color and carries a permanent negative charge. These 'electrophoretic' pigments make

FIGURE 4. A commercial digital cine projector from Barco.



E-ink electrically active. Sandwiched between two conducting polymer sheets, each microcapsule becomes a single monochrome pixel capable of showing up as either a white or a black dot, depending on which pigment faces upward toward the viewer. Either of the pigments could be made to face the viewer by applying an appropriate voltage to a pair of transparent conducting tracks underneath the chosen microcapsule. The pigment steering action is fairly quick and can result in a pixel becoming white, black, or gray, depending on the voltage configuration (see Figure 5). The possibility of intermediate or gray configuration results in a pleasing display quality.

Transition from one color state to another takes place in less than a second. Once a pixel has been switched to one of its three possible color states, no further power consumption is required as the state can be maintained indefinitely. The resolution of such a display is ultimately limited by the diameter of the E-ink microcapsules that is roughly the same as that of a human hair. Pixels of such a size are well-suited for most all display applications ranging from public signage to screens for portable and handheld devices. Due to their slow switching speed, present-day E-ink technology is not suitable for displaying moving images, but there are still plenty of applications where this kind of display can be usefully employed.

The outstanding advantages of E-ink-based displays are their high contrast (the same as that of black ink on paper), extremely low power consumption (power is only needed when a displayed image is changed), all-angle viewing capability, very low weight, and thin form factor. To these can be added its inherent flexibility which will be fully utilized once flexible backplane display-driver electronics are developed. Futuristic developers are already talking of the days when flexible display technology will make personal flexible newspapers a reality.

The Potential of E-ink

Due to its outstanding advantages, several products employing E-ink technology are being released or are under

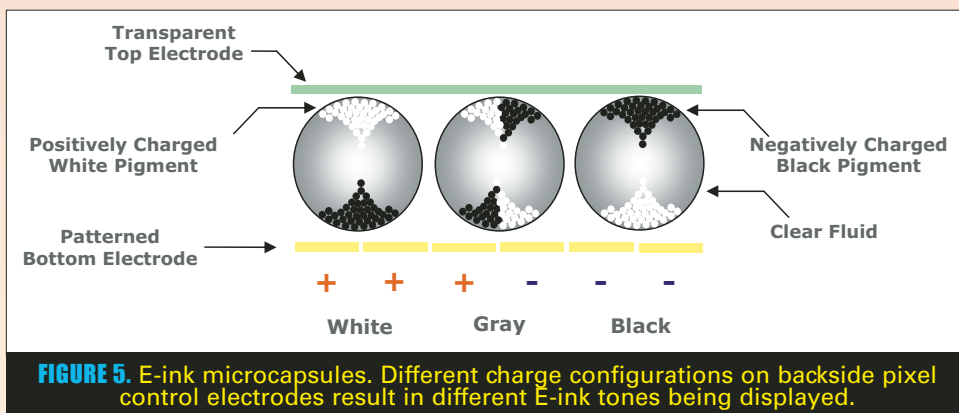


FIGURE 5. E-ink microcapsules. Different charge configurations on backside pixel control electrodes result in different E-ink tones being displayed.

development. These include electronic books, Personal Digital Assistants (PDAs), flexible clocks (see Figure 6 for a prototype from Citizen Watch Company), Flash memory sticks with usage indicators, indoor weather stations, and more. Recently, a color version of E-ink has also been introduced — a development that will further diversify the range of electronic ink-based products that are possible. As this technology matures, more and more developers are likely to jump on the bandwagon so that we can expect to see more E-ink products in the future.

What Lies Ahead

With several distinct display technologies competing out there for commercial success, what can be said about the future? While all technologies will be improved over the coming months and years in order to bring down their costs and to improve their operational aspects, they will mostly find their own niches.

PDP and LCD have been direct competitors and are likely to remain so, especially because efforts are underway to make larger LCD screens that could compete head-to-head with PDPs in the large screen arena. Other than that, unless something gives one or the other a definitive technological advantage, the choice among them will continue to be dictated by consumer tastes.

DLPs have replaced CRT-based projection TVs and these appear set to remain in this role as the new sets are smaller and display much

superior images. This technology is also enabling the development of digital cinemas which will become ubiquitous in the next few years. The delays here are not technical but rather commercial and logistic; stemming from the inability of the film industry to reach a consensus on rights management, content distribution, and security provisions.

As progress is made on these issues, we will see widespread adoption of digital projection standards in the near future. E-ink, being a static display technology, is unsuitable for televisions but — by all indications — will see widespread use in electronic books, personal gadgets, and information signage. Its utility will be boosted further by the recent development of colored E-ink technology.

By all accounts, the diversity of emerging electronic image reproduction standards will both satisfy existing needs and spawn brand new markets. Taken together, the new display technologies will define much of the look and feel of the early 21st century, and in the process, will make our lives more vibrant and colorful. **NV**



FIGURE 6. Citizen recently demonstrated the world's first flexible clock made from E-ink.

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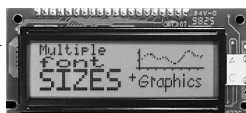
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Reno Air Races 2006



An old-fashioned fire-truck drove pilots and crew up and down the flight line after flight demonstrations or race heats.



If you squint your eyes, and look into the haze, the line-up of unlimited air racers looks like a military flight line of World War II.

by Brian Mork

Have you ever noticed that national aviation events tend to pick up names based on where they occur? For example, the home-built Experimental Aircraft Association (EAA, www.eaa.org) fly-in, conducted annually in August in Oshkosh, Wisconsin, is colloquially known as “Oshkosh.” The Reno Air Racing Association (RARA, www.airrace.org) air races, held annually in September at the Reno-Stead Airport in Nevada, are known simply as “Reno.”

I had a chance to attend the 2006 races, held September 11-15, and took the opportunity to learn a bit about the teams, see what opportunities there are for people, take a lot of photos, and see what hardware and software they’re using to push forward this “World’s Fastest Motor Sport.”

Previously, I reported on the 2004 and 2005 DARPA Autonomous Vehicle competitions and 2005 X-Prize win for the Space Ship One team. These were cutting edge efforts, pushing new technology to the limit. Although the team that took first place in the Reno Sport Class develops aircraft at the same Mojave Spaceport as the Scaled Composites Space Ship One team, the character and purpose of Reno is different.

Reno is not a free-for-all run toward the future, with new technology oozing out of every mechanical seam. It’s an honorable and traditional discipline pursued by those with the money and dedication to win with margins of victory hovering at a few percent, any

tiny errors leading to magnificent loss.

Individual teams are always looking for new ways to improve, and adopting data collection and analysis techniques is one of many methods helping them squeeze the last mph out of their aircraft and pilot techniques. What is this environment, and who are these people? What kind of technology do they use? In what areas could I contribute? These questions form the scope of this article. Please be sure to also read the many photo captions — much of the spirit of Reno comes out through the photographs.

Race Aircraft

There are six broad classes of competition, based on the type of airplane.

- The traditional fast movers are the Unlimited Class. Until recently, any propeller driven airplane could participate. This class is populated with propeller driven World War II type planes with stock or modified engines, wings,

etc. Some modern lower-power, low-weight designs are starting to threaten the speed zone previously owned by the best WW-II speedsters. In response, the RARA committee added an additional minimum weight restriction to keep the character of the race. Past wins have been above 450 mph, and are pushing against 500 mph as improvements are made each year.

- The Jet Class exhibits the fastest raw speed, but doesn’t have the same audience thrill of deep throated aspirated engines as they zoom by a couple hundred feet in the air. All aircraft in this class are L-39 Albatross jets.

- The Sport Class was started in 1998 to include any number of the faster home-built type aircraft. As optimization set in, the class has become dominated by Glassair and Lancair fiberglass airframes.

- Formula One pilots fly aircraft built to strict technical specifications. Speeds of nearly 250 mph are



Detonation is when the conditions in a piston engine cause premature explosion of the fuel mixture, providing expanding pressure when the piston is at the same time trying to compress the fuel mixture. During one of the qualifying runs, this \$200,000 Merlin engine was allowed to detonate just a second too long. The piston flew down into the crankcase, damaging many parts until it finally tore through the body of the engine.



The sport class is dominated with composite construction, retractable gear Glasair and Lancair aircraft. These are not exotic specialty craft. Just a few years ago, many racers were stock. To squeeze the last 10-15 mph out of them, increased customization is the trend in the air race community. If you have the money, and reasonable shop skills, you can build one of these planes. Check websites at www.lancair.com/Main and www.glasairaircraft.com. Think \$50,000 to get started, five years to complete. Finished planes sell for over \$100k.



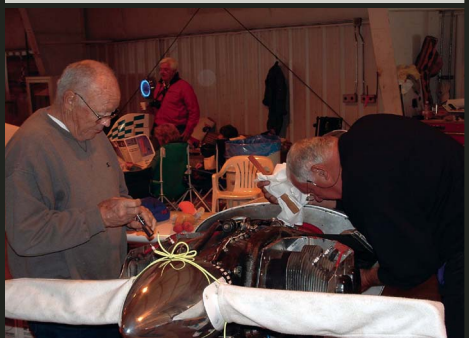
Five people working simultaneously on the same engine was not abnormal. Notice the two halogen spotlights in the foreground to keep working into the night.



These planes look very similar as they round the southwest pylons traveling over 200 mph. If you look close, you can identify a Glasair by the bow in the canopy, and the Lancair by the one-piece canopy. Sport Class champion speeds have gone from 308 mph in 1998 to 365 mph in 2005.



Part of the Unlimited Class lineup race pit area after a day of qualifying runs. A Hawker Sea Fury from Nevada and two from Texas, join a Grumman F8F-1 at the far end of the line.



The Formula One aircraft are tightly constrained in form and size, so much of the competitive advantage comes from tuning the engine and propeller to deliver every last pound of thrust into the air-stream zipping by at about 250 miles per hour. Sometimes, it seemed the effort was led by technology, and sometimes good-old fashioned savvy experience.



The Nemesis racer in the Sport Class was optimized to beat the Lancairs at the Reno air races. For aerodynamic reasons, as the Nemesis is taxiing, the pilot can't see the runway in front, so the team mounted a remote camera on the landing gear. After two years of landing gear trouble, John Sharp and the Nemesis won this year at 360 mph around the 6.4 mile course.



The Air Force F-15s didn't participate in the race, but they did multiple air shows throughout the days. With the track clear, the pilots usually ended their routine with a lap around the track — clearly trouncing times of normal competitors.

attained on a 3.2 mile course. The following description comes from the www.if1airracing.com website (that's a "one", not "el" in the URL):

"Established in 1947 as an alternative to the (even then) outrageously expensive unlimited class, Formula One racers have been evolving for almost 70 years. Today, the top racers use NASA technology to reach top speeds approaching 300 mph on the same engine that powers a Cessna 150 to barely 100 mph. International Formula One is without a doubt the most affordable form of world class motor racing."

- T-6 is a class defined by the airplane, but kept alive by the spirit of a community. The Condor Squadron out of Van Nuys, CA airport is a good example. In 1967, former Guardsman from the 146th Airlift Wing formed the Condor Squadron (www.condorsquadron.org) as a search and rescue unit associated with the Civil Air Patrol and for the enjoyment of flying the vintage North American Texan AT-6, originally used in World War II training missions. The aircraft fly in formation weekly and participate in patriotic, charitable, and memorial activities. Several of their planes were at Reno.

- All aircraft in the Biplane Class need to have (surprise) two wings. There are some technical limits on what constitutes a wing, but basically the intent is to include what a common person would identify as a bi-plane. This class

is dominated by Pitts (wikipedia.org/wiki/Pitts_Special), but also has a few designs optimized to go fast and do little else well.

For all classes, the engines of the aircraft are the philosophical center of gravity for the entire airplane. For the Unlimited class war birds, it's not uncommon to use a heavily modified, turbine-driven carburetor-aspirated engine, with manifold pressures above 120 inches of mercury. Inter-cooling is mandatory, and loss of the water system or the electricity that runs it is an immediate emergency grounding for the airplane.

Competitors run aggressive timing advances so that every possible molecule of burned fuel adds pressure to the downward stroke of the pistons. Threat of detonation is real. See the photo of the engine that threw a piston out the side of the casing on the previous page. Unique to Reno is that even with an engine blow-out like that, the press was happy to report "no serious accidents" for the week. It's a recognition that what could happen is much worse.

On the other end of the scale are the Formula One racers, where all planes are powered by a 200 in³ Continental engine, which is the small 100 Hp engine used in a Cessna 150 trainer. The weights and size of every major part must be within stock limits, and the cam profile and carburetion are strictly controlled.

Pulled through the air with these

extremes, airplane speeds clock in between 200 mph and nearly 500 mph. Race results are available many places on the web, and reported in many aviation-oriented magazines or websites. An interactive web query can be found at www.airrace.org/2006ResultsQuery.php. The fastest times for each category this year were as follows:

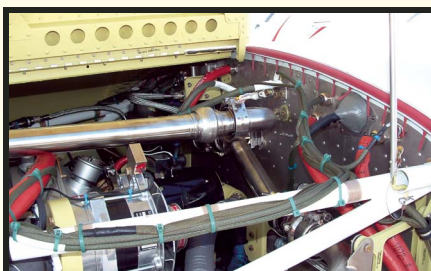
Class	Airplane	Pilot	Speed (mph)
Unlimited	September Fury	Mike Brown	482
Jet	American Spirit	Rick Vandan	443
Sport	Nemesis	Jon Sharp	360
F-1	Mariah	Gary Hubler	257
Biplane	Phantom	Tom Aberle	252
T-6	Six Cat	Nick Macy	236

Culture

The people who own and pilot these aircraft are not your normal blue-collar, 8-5 employees. Most of the Unlimited aircraft are owned by business owners, airline pilots, or people retired from a business closely related to aviation. The owners don't necessarily fly the planes.

Pilots may be tied to one team year after year, or free-lance each year. But not just anybody can fly in these races. If you intend to fly in September, you have to attend a four-day Pylon Racing School in the prior June, or have raced in the same class within the past three years.

Free-lance pilots such as Skip Holms are perennially at the race, appearing in race results every few years. On a Lake Tahoe dinner cruise, I had the privilege of chatting with Skip



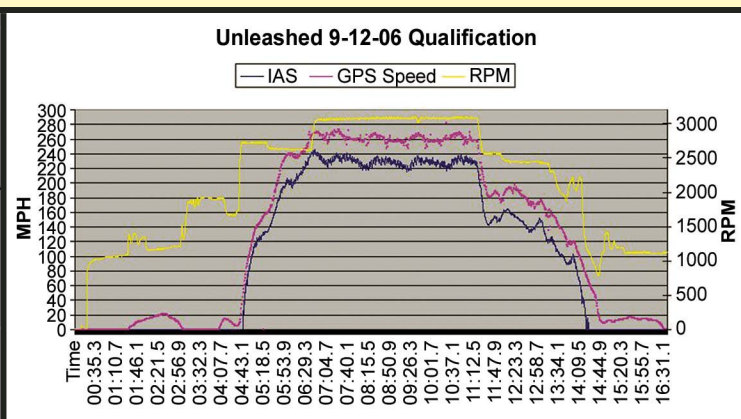
If you're used to working in the grungy engine compartments of road vehicles, aviation installations would impress you. Big enemies are vibration, heat, and potential for fire. Almost all the assembly techniques you see here — such as cable sheathing, strapping, ferrules, and feed-throughs — are mandated by FAA regulations.



The mix of old and new military planes is increasingly getting rare. Several times per day, military formation flybys were done with a mix of World War II, Korean War, Vietnam War, and modern fighters. If you have expertise that can help old planes stay airworthy, there are multiple organizations or private owners that would value your contribution.



Six Unlimited class aircraft make the turn back to the North on the Southeast corner of the race track, directly in front of the audience. Visible in the picture are the emergency vehicles ready to respond. Races were flown only 100 feet or so above ground level, with very little time for mistakes. Fortunately, this year, there were no serious accidents.



This data shows a flight of the Lancair 360 "Unleashed," which placed 6th in the Bronze Sports Class, at 259 mph.



This is the cockpit of one of few Sport class aircraft that used data acquisition systems during the races. Flight instruments are on the left. Technical data information is presented on the right.



The staid Cessna Citation business jet has been retro-fit with two Williams FJ44-2A turbofan engines and designated the "Stallion" by Sierra Industries of Uvalde, TX. Even more than cars, the engine inside an airplane gives it character to both the pilot and to the business managers monitoring costs. The engine re-fit, in this case, cuts down on weight, size, and fuel consumption, while improving performance numbers. The Stallion climbs directly to FL340 (34,000 feet), and cruises for 1,400 nm at 380 knots, burning only 620 lb/hr of fuel.



A venerable P-51, taxiing out for a flight demonstration (no team number on the tail indicates that this was not a race bird).

for the evening, and came to appreciate the breadth of experience he (and I'm sure many race pilots) have. When not active on a team, he's part of a new aviation business (www.maverickjets.com/team/skip.php).

The mechanics are a special breed. Not everybody knows the ins and outs of these engines and planes. But knowledge isn't enough. During race season, care and feeding of a race plane becomes one's life. Spouse or kids travel with you, and you, in-turn, travel with the plane. Many team members live in an RV trailer on the ramp during race week. Between races — day or night — it's not uncommon to have swarms of people around the planes, with engine cowlings pulled.

Oftentimes, teams become populated with volunteers and families, doing the entire race season for recreation. The Formula One, Biplane, and Sport Class continue most strongly with this character, although the Sport class has drifted toward special race-only aircraft, relying on contract-hired work of experts.

The costs of racing a plane is significant. To take the edge off, many teams have a full-time booth selling fan paraphernalia — hats, t-shirts, emblems, jackets, and sometimes even rides in the plane during quiet times.

Data Collection

Ray Debs is partnered with Curtis Weinman to build, own, and race Formula One aircraft (www.aerophile.org). This year, they moved up to the Gold competition for the first time, and placed fifth, flying #81, "Carbon Slipper."

Ray also has a strong background and continued interest in model plane racing. This connection opened conversations with Mike Luvara, of RCAT Systems (www.rcatsystems.com), who traditionally developed data systems for radio-controlled aircraft.

Teaming together in 2003, they flew the first data collection systems in the Reno air races. It was a classic cooperative sponsorship where both

sides benefitted. Mike learned a lot about engineering "laboratory grade" data acquisition systems for hard life in a magneto driven, high RPM engine environment. Ray was one of the first beneficiaries of a real-time data display, and after-race analysis to determine what could be optimized.

Currently, Carbon Slipper has equipment in place to monitor four Cylinder Head Temperatures (CHTs), four Exhaust Gas Temperatures (EGTs), Air Speed, GPS-based Time Space Position Information (TSPI), Oil temperature, RPM, and N_z (vertical acceleration, or gravity). Real-time telemetry is transmitted to a laptop on the ground during the race. Panel indication to the pilot announces if anything is approaching limits.

With this Formula One start, the RCAT system has become the dominant data acquisition system at the Reno air races. In addition to Formula One, several of the serious Unlimited class teams use the system. For example, September Fury — which won the Unlimited class competition — uses an RCAT system. During the race week, Mike was resident on-site helping teams get the most from his hardware and software. I included pictures of several screen shots, giving an idea of what type of data is streamed to the ground during a race, and what type of after-action analysis can be done.

Data Technology Improvements

I've had a chance to work with multiple data collection systems at the USAF test pilot school, and the automotive manufacturing industry. Actually collecting data from almost anything is getting to be "old hat." Intelligent use of the data is a wide open field. Do you have ideas? Get in touch with a team, and start volunteering your time.

Race teams' big concern is engine life and performance. The two are often at odds, and optimizing the combination often runs parameters against the limit. Some sort of warning system when limits are exceeded is by far the most valuable contribution of the data systems. Monitoring by a ground team during a race is wise. There are mixed

opinions about putting displays in the cockpit because traveling at 300 mph, less than 100 feet above ground, demands most of the pilots' time. Some teams use nothing in the cockpit; some use a simple red light annunciator, and some use data displays.

After-action analysis may contribute most to the year-to-year improvements. With proper analysis tools, pilots can learn to take advantage of prevailing wind on the track, or build reference data sets of optimum settings, based on ambient weather conditions. RCAT Systems was there this year overlaying position data on top of Google Earth images, giving instant visual display of variations, lap to lap. Improvement may come in the form of trend analysis or pattern recognition of what airframe and pilot technique combinations obtain the best speed.

This technology area is not limited to individual race teams investigating how to use reams of real-time and historical data. Using data well is the core goal for one of the Small Business Innovation Research (SBIR) government grants I'm familiar with, that is specifically funding new methods of using aircraft test data. If you visit the Increa.com Wiki, and search for "SBIR," you can read contract and technical summaries of the work being done.

If your company can do development in this area, you may want to monitor what other requests are coming from the government. Check the SBIR solicitations that come out multiple times per year (www.sba.gov/sbir/indexsbir-sttr.html) for contracts that range from \$100k to over \$700k.

On a smaller scale, if you're interested in volunteering time with any of the teams, contact them now as race improvements are a year-round activity. If you're interested in wandering the ambiance of a modern day air race next September, check prices and schedule on the RARA website. Camping locations start to fill up mid-summer, so plan ahead. Although air racing has been around for 60+ years, the improvements keep happening. Whether you contribute on a team, or watch as a spectator, I hope you'll have a chance to enjoy this one-of-a kind sport! **NV**

ABOUT THE AUTHOR

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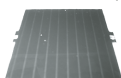
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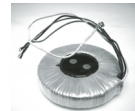
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GETTING STARTED WITH PICs

THE LATEST IN PROGRAMMING MICROCONTROLLERS

■ BY CHUCK HELLEBUYCK

QUICK AND DIRTY HOCKEY SCOREBOARD

ONCE YOU LEARN HOW to control an LCD module, you suddenly see them all over the place and numerous ideas for LCD projects come to mind. Over the years, I've done many projects with LCDs, and the whole LCD business has grown to the point that just about every kind of LCD you could imagine is available.

Serial LCDs that receive information in RS-232 style format are popular and have come down in price. Parallel LCDs — which require a little more software to drive — are popular because they can be bought in surplus for around \$10. LED backlight LCDs are also readily available in lots of different colors. I've also received a lot of email from new readers to the column asking for more LCD examples. I pulled a little project out of my library for this month to show how having a development board with built-in

LCDs can really come in handy. I'll also show that the Atom software makes driving one of the lower cost parallel LCDs as easy as driving a serial LCD because of the LCDWRITE command.

SCOREBOARD

Several years ago, I created one of my most favorite Atom development boards that I call the BasicBoard. I tried to put all the features in one board that I use most often in my projects. The BasicBoard has switches, LEDs, speaker, potentiometer, serial port, expansion ports and — of course — an LCD. I used a 40 pin Atom interpreter chip at the center of

it, it's when kids play hockey on their knees using those little plastic souvenir hockey sticks and a soft, round ball. He often plays until someone gets to 10 or 20 goals, but my knees can't take that, so I wanted to put a time limit on it. I didn't have time to build a whole setup, so I pulled out a BasicBoard and in a short time had a whole scoreboard developed as seen in Figure 1. I wasn't real worried about accuracy of the time, but since the BasicBoard used a 20 MHz resonator and I was only looking for a 20 minute timer, this setup was accurate enough. In fact, I didn't even need to use a timer interrupt. I could just use a simple PAUSE command to get the right timing.

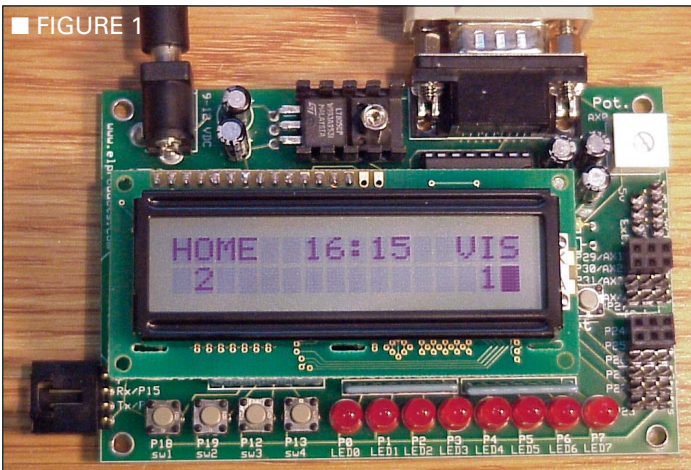
I got a little carried away and added a score to the setup since it didn't take much more effort and I had the space on the LCD. Having the switches and LEDs pre-connected also made this simply a software project. The original scoreboard had a second timer to tell when to change lines in case my son had a group of kids playing that were taking turns. I removed that portion for this article.

If you're not familiar with mini-stick hock-

NOTE:

■ The complete software listing is available on the *Nuts & Volts* website at www.nutsvolts.com

■ FIGURE 1



HOW IT WORKS

Using the CON (constant) and

VAR (variable) directive, all the variables are established, the first being the speaker connection. It's easier to understand that "spkr" is speaker rather than p20.

00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	← Character position (dec.)
00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F	10	11	12	13	← Row0 DDRAM address (hex)
40	41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F	50	51	52	53	← Row1 DDRAM address (hex)
14	15	16	17	18	19	1A	1B	1C	1D	1E	1F	20	21	22	23	24	25	26	27	← Row2 DDRAM address (hex)
54	55	56	57	58	59	5A	5B	5C	5D	5E	5F	60	61	62	63	64	65	66	67	← Row3 DDRAM address (hex)

■ FIGURE 2

```
spkr con 20          'Initialize Speaker Connection
```

Next, the variables required to store the time and display values are reserved in RAM using the VAR directive. This program only needs byte-size variables.

```
tns var byte          '0x:xx 10's digit display variable
mns var byte          'x0:xx 1's digit display variable
scs var byte          'xx:0x 1/10's digit display
ths var byte          'xx:x0 1/100's digit display
mn var byte           'total minutes variable for clock
sc var byte           'total seconds variable for clock
hscore var byte       'Home Score variable
vscore var byte       'Visitor Score variable
```

The LCD needs to be initialized as a 2x16 LCD with the cursor block visible and blinking (scrblk). This command also clears the display (clear) and puts the cursor at the first position (home). We also pause 500 milliseconds before this command to allow the LCD hardware to power up properly.

```
' *** Initialize LCD to 2x16 *****
pause 500
lcdwrite 17\16,outc,[initlcd1,initlcd2,twoline,scrblk,
clear,home]
```

Next the program confirms the display is working by showing "ScoreBoard" on the first line and delaying it for one second so we will see it.

```
' *** Initialize Section *****
main

' *** Display Banner of "ScoreBoard" for 1 second ***
lcdwrite 17\16,outc,[clear,home,"ScoreBoard"]
pause 1000
```

The program also has to initialize the clock and score. This is done by initializing the variables.

```
' *** Initialize clock to 20:00 and Home 0 vs Visitor 0 ***
init
mn = 20
sc = 0
hscore = 0
vscore = 0
```

The time is actually broken out from the two time variables by math functions. We get the first digit by dividing by 10, then use the remainder for the ones digit. We do the same for the two digits beyond the decimal point. This is a simple way to break up a number into

individual digits to be displayed on an LCD.

```
' *** Create timer values to be displayed ***
tns = mn/10          ' Ten's digit is minutes divided by 10
mns = mn//10         ' One's digit is the remainder
scs = sc/10          ' Tenths digit is seconds divided by 10
ths = sc//10         ' Hundreths is the remainder
```

The calculated data is displayed on the LCD. The second line is controlled by the SCRRAM+\$40 command. The second line position starts at 40 hex on the LCD character map inside the LCD display, as seen in Figure 2.

The position you want is then added to the value. Notice I add "14" to position the visitor score and it is treated as decimal 14, not a hex value. This is because the Atom compiler doesn't see a '\$' in front of it, so it converts it and does the math. Nice little feature.

```
' *** Display the time on the LCD ***
lcdwrite 17\16,outc,[Clear,home,"HOME ",dec tns,
dec mns,":",dec scs,dec ths," VIS"]
lcdwrite 17\16,outc,[scrram+$40+1,
dec hscore,scrram+$40+14,dec vscore]
```

The main loop is entered next. This just decrements the clock and updates the display in a similar fashion to what we did earlier. The only difference is the clock decrement calculation. Also notice the "pause 975" at the top of the loop. This is a crude adjustment for accuracy to make the loop close to one second. I just timed it next to a stopwatch via trial and error to get that number. In fact, it's probably a little off since I removed some code from the original program for this article. You will have to adjust that by making it slightly larger.

```
' *** Main Loop of Code ***
loop

pause 975          ' Adjustment for accuracy of
                  ' clock
if sc <> 0 then      ' Test if seconds is not zero
sc =sc - 1          ' Reduce seconds by one
elseif sc = 0 and mn > 0
                  ' Seconds is zero so test
                  ' minutes also
sc = 59             ' Reset seconds to 59
mn = mn - 1         ' Reduce minutes by one
endif
```

The Home score and Visitor score are next. All these sections do is look for a switch to be pressed. If one of the switches is pressed, the score is incremented and then it waits for you to release the switch. This is actually lousy code writing because holding the button stops the clock. It also requires you to hold the switch for almost a second

because of that long pause 975 delay. (This is the cost of doing something quick and dirty so my son wasn't waiting forever for me to finish.) If I would have used a timer interrupt as the clock base, I could have made the main loop shorter and scanned the keys quicker without ever messing up the clock accuracy.

```

*** Check for home score ***
if in19 = 0 then      ' If P19 switch is pressed
hscore = hscore + 1  ' then increase home score

*** Update Display *****
lcdwrite 17\16,outc,[Clear,home,"HOME ",dec tns,dec
mns,":",dec scs,dec ths," VIS"]
lcdwrite 17\16,outc,[scrram+$40+1,dec hscore,
scrram+$40+14,dec vscore]
endif

**** Wait for switch to be released ***
holdh
if in19 = 0 then holdh

**** Check for VIS score ***
if in12 = 0 then      ' If P12 switch is pressed
vscore = vscore + 1  ' then increase visitor score

**** update display *****
lcdwrite 17\16,outc,[Clear,home,"HOME ",dec tns,
dec mns,":",dec scs,dec ths," VIS"]
lcdwrite 17\16,outc,[scrram+$40+1,dec hscore,
scrram+$40+14,dec vscore]
endif

**** Wait for switch to be released ***
holdv
if in12 = 0 then holdv

```

Next, we'll use the pause 975 "feature" to actually stop the clock. It reads the switch the same way it reads the score switches, but this time holds until the switch is pressed again. Switch bounce could be a problem here, but the time to set the LED allows this to work well. If this wasn't the case, it could actually see two presses because

the contacts of momentary switches can internally bounce, causing multiple contacts which can be read as two or more presses. The Atom is a little slower than a compiled PIC, so this is less of an issue.

```

*** Freeze Time ***

if in18 = 0 then      ' If Switch 18 is pressed then
high 7                ' light LED7 and
holdt                 ' hold up the clock
if in13 = 1 then holdt ' until switch is pressed again
low 7                 ' Switch pressed LED7 off
endif

```

This last section tests the clock values to see if they are at zero. This indicates time is up so the SOUND command is used to drive a tone from the speaker. The program also pauses the program after the tone is complete and waits for the user to press the P13 switch. When the switch is pressed, the program jumps back to the top and resets the clock to 20:00 and clears the score. The timer then starts running again. If the clock isn't at zero, then this section is skipped and the program jumps to the loop label.

```

' *** Check for Main Clock Time up ***
if sc = 0 and mn = 0 then ' Test for time = 0
high 7                    ' time up light LED7
sound spkr, [8000\200]    ' Play time up tone for 8s
tuhold                    ' Hold up program until switch 13
if in13 = 1 then tuhold   ' is pressed as reset switch
low 7                     ' LED 7 off
mn = 20                   ' Reset time to 20:00
sc = 0
goto loop                  ' Loop back to do it all again
endif

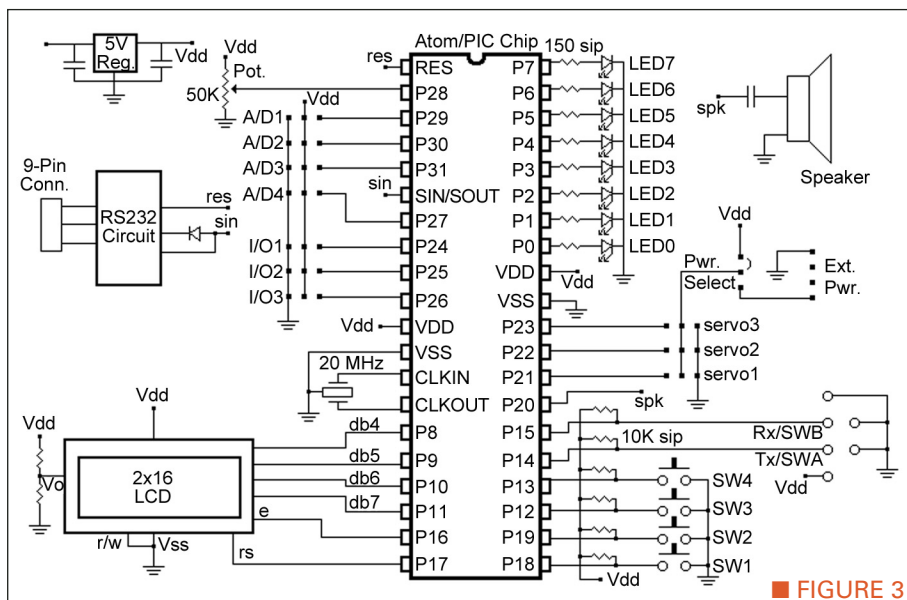
goto loop                  ' Final loop if all else passes

```

There are lots of areas to shorten this code. All the display commands could be combined into a subroutine, as well as some of the calculations of display digits. However, shorter code wasn't my goal. A quick solution to save my knees was all I was looking for.

HARDWARE

The schematic for the BasicBoard is shown in Figure 3. The schematic shows four momentary switches pre-wired to the Atom PIC with external pull-up resistors. I put eight LEDs all connected to PortB (P0 thru P7) through a 330 ohm resistor bank. The speaker is prewired to P20 pin through a 10 µF cap which is an easy way to create sound (as shown in the December 2006 article). The LCD is a simple four-bit connection scheme. I don't have it wired for back-light operation.



■ FIGURE 3

This setup is easily built on a breadboard if you have the components lying around. I personally like laying out these types of development boards. Call me crazy, but I find it a lot of fun. It costs more initially, but saves time in the long run. I do get many emails asking me which development board I recommend and frankly, I don't really know. I like mine since I designed them, but everybody has their own preference. In most cases, you are spending a lot of money for these boards so you want as many options as possible. I guess that even becomes a problem because you may have too many choices that require all sorts of jumpers and more difficult software setup. You also end up paying for features you may never use.

My Ultimate OEM modules resulted from all that experimenting. So don't be afraid to shop around to find what you think will work for you, and then have a couple around for simple projects like this scoreboard that happen to come up. Just the savings in time from having all the connections pre-wired is well worth the cost.

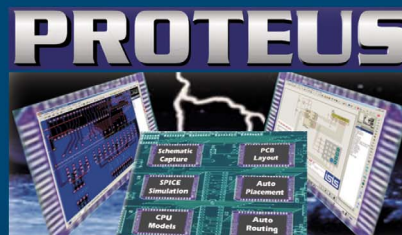
SUMMARY

It's little projects like this that build up your skill over time. Once you have a few development boards lying around, you'll find yourself writing quick snippets of code to test something out. Soon you will have a library of sample code for creating all kinds of little gadgets. I've found it's the hardware that takes so long to get right. This is why I've developed all the breadboard modules that are on my website (www.elproducts.com). I use them to quickly plug and play ideas and then use that knowledge in future projects. They don't eliminate the hardware, but reduce it down to a few jumper wires. When you want to make something quick just to prove that it will work, you cannot beat the simplicity of a pre-built development board.

The Atom also adds a lot of simplicity since you don't need to use a separate programmer to get the code into the PIC. Just a simple serial connection will work. I've even tested the BasicBoard with a few RS-232 to USB adapters and most worked well. You still need to supply separate power, though. Look for that option when searching for a development board. Serial ports are getting harder to find especially on laptops. If you can find a board with USB to RS-232 built in, that is great. There are new chips out that make that easier to implement. Some PICs even have USB built in (I'll be writing about that in future articles.)

Another advantage to the development board route is that the code is proven first and then you can focus on improving the hardware. For example, you could drive large LED displays and make this setup a real scoreboard. I've seen LED arrays form seven-segment digits that are five inches tall. Plenty big enough for a full scale scoreboard.

Keep those emails coming! I enjoy reading them all. I get a lot of junk mail also, so if I don't respond, I probably missed it because the spam filter got it. I try to respond to everybody's email. If you sent it to me and didn't get a response, please try again. It's chuck@elproducts.com. See you next month. **NV**



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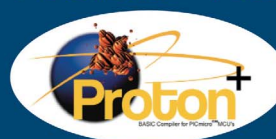
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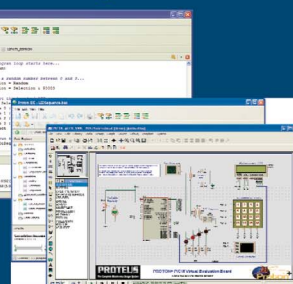
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■ BY LOUIS E. FRENZEL W5LEF

TESLA INVENTED RADIO, NOT MARCONI!

Get Your History Correct and Give Credit Where Credit is Due

OKAY, I AM PROBABLY AS GUILTY AS YOU in believing that Marconi actually invented radio. But he did not and it has taken decades — actually, over a century — for the truth to come out. In fact, I am convinced that the truth is still not well known. Not to burst your bubble or anything, but here is the real story.

WHAT REALLY HAPPENED?

My son-in-law recently gave me a book he found on a sale table called *Tesla, Man Out of Time* by Margaret Cheney. It has a 1981 copyright date on it, but was re-released in 1993. My son-in-law is not a technical or

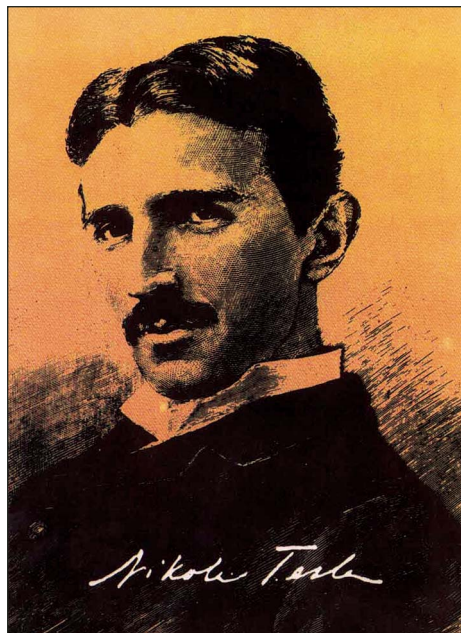
electronics type, but he read the book and was fascinated by Tesla and even amazed at Tesla's unbelievable inventions. Tesla was not only a real success in the electrical fields, but also a terrible failure in many ways. And one of those failures was his inability to get recognition for inventing radio during his lifetime. I read the book only to find that I have had it wrong all these years myself. From my days as a ham radio addict in my teens to today where I write books and articles on radio for a living, I firmly believed I owed my livelihood to Marconi.

Nikola Tesla was born in the Serbian part of Croatia in 1856. Last year was his 150th birthday. He began inventing as a boy. Tesla was educated in various European universities in mechanical and electrical engineering, physics, and languages. During the late 1800s, he worked for Thomas Edison's European telephone company in Budapest and Paris. He

immigrated to the US in 1884. He worked for Edison in New York City for a while, but pursued inventions on his own with great success. After endless squabbles with Edison over the merits of DC vs. AC, Tesla took off on his own and invented a whole stream of electrical things and patented them. Some of them were improvements to the telegraph, arc lights, and all manner of electrical machines like generators and motors. One of his best inventions was the AC induction motor which he sold to Westinghouse.

Tesla went to work for Westinghouse and helped him eventually win the battle for electrical power distribution in the US and elsewhere. Edison was hell-bent to electrify everything with DC, but found that it was very inefficient and required more generating stations over shorter distances. But AC — with its ability to be stepped up in voltage by a transformer — could be transmitted efficiently over very long distances then stepped back down to usable levels where it was to be used.

Tesla was a major player in building the first big power-generating



Photos are courtesy of Dr. Ljubo Vujovic, General Tesla Memorial Society of New York (www.teslasociety.com).

■ FIGURE 1. Nikola Tesla in 1895 (age 39).

plant at Niagara Falls, NY. In any case, he was a major player in making AC the electrical power of choice. And despite his essential role and success, he never got rich like the Westinghouses and Edisons of his time.

His number of inventions and patents runs into the thousands but few — if any — actually paid off big for him. He did manage to live comfortably for years in New York City hotels from his royalties and occasional funding for research by a stream of rich benefactors. In general, Tesla was just too distracted by his active mind to patent or otherwise protect everything he invented. And that is more or less why he never did get credit for inventing radio despite the fact he did patent it in the US the same year that Marconi got his first British patents. Tesla was very good at getting press coverage for his work, but Marconi came along and captured all the glory and credit before Tesla realized what was going on.

Tesla actually invented the idea of radio in 1892 — not too long after Heinrich Hertz demonstrated UHF spark wireless transmissions in Germany in 1885. In 1898, he developed a radio-controlled robotic boat which he demonstrated by driving the boat remotely around the waters of Manhattan from a set of controls at Madison Square Garden. But despite this amazing feat, he tried for years to sell the idea to the Navy without success.

Once realizing the importance of radio, Tesla actually built a huge transmitting tower at Wardenclyffe on Long Island in 1900 to develop worldwide radio transmission services. He ran out of money and could not raise the capital to continue. He actually went bankrupt, thus ending his formal radio research and development.

WHAT MARCONI ACTUALLY DID

Guglielmo Marconi was born in Italy but lived in England. He experimented with Hertz's spark apparatus and developed improvements to

extend the transmission range to one mile, then hundreds of miles. He received British patents for his radio inventions. In 1901, he demonstrated the first trans-Atlantic radio transmission. He went on to form a wireless telegraphy business for the British. While all of the first patents related to spark wireless, the real important patents were for continuous wave (CW) transmission on one frequency. Spark gap transmitters radiated a very broadband signal on no particular frequency. CW signals used the resonance of tuned circuits and antennas.

Marconi's real contributions are more engineering and commercial than theoretical. He took the basic ideas and inventions of others and improved upon them and made them practical business successes. Tesla was almost the opposite. He created original ideas and proved them mathematically and physically, patenting some and not others. Some of his best ideas like the AC induction motor was a commercial success which brought him fame but not riches. Marconi, of course, was fabulously rich.

A patent battle between Tesla and Marconi went on for years. Marconi died in 1937. Tesla died in 1943 and six months after his death the US Supreme Court ruled that all of Marconi's radio patents were invalid and awarded the patents for radio to Tesla. So, for the past 64 years, we still believe that Marconi invented radio. Few actually know of Tesla's radio inventions. He is — of course — well known, but for his strange experiments with high voltage, lightning, and the claim he had invented not only an electrical "death ray" but a way to transmit electrical power wirelessly.

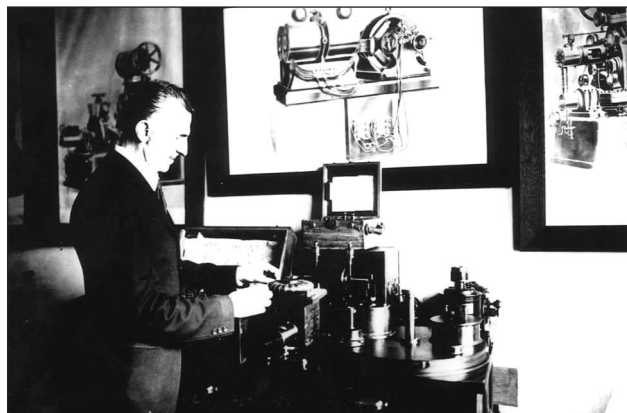
THE INVENTION OF RADIO

Like most signifi-

■ **FIGURE 2.** Nikola Tesla in his 60s adjusting a radio device in his lab in New York City.

cant inventions, radio had not just one "father," but many. British mathematician James Clerk Maxwell first proved the existence of radio waves mathematically in 1864. The German physicist Hertz set out to prove Maxwell's equations and did so in 1885. After that, lots of others jumped into the fray. Some of them included Briton Oliver Lodge, Indian physicist Jagdish Chandra Bose, and the Russian Popov. And none of this would have happened unless Edouard Branly invented the coherer — the first real detector of radio waves. This device used metal filings inside a glass tube that served as a kind of crummy but sensitive diode detector.

Radio or wireless was strictly a telegraphy medium until the vacuum tube was invented. The first tube diode was invented by John Fleming of England in 1904. In 1906, American Lee de Forest invented the triode vacuum tube that quickly made radio even better because of the amplification and oscillation it could provide. Reginald Fessenden then made the first AM radio broadcast in 1906. By the 1920s, there were hundreds of radio stations in the USA. Edwin Armstrong invented FM in 1933, but lost the patent battle with RCA, and committed suicide shortly thereafter. Then in 1947, Shockley, Bardeen, and Brattain at Bell Labs invented the transistor which Shockley later perfected into the transistor as we know it today. In 1957 and 1958, Jack Kilby (Texas Instruments) and Robert Noyce (Fairchild, later Intel) invented integrated circuits. And the rest, as they say, is history. **NV**



■ BY PETER BEST

USING ETHERNET INSIDE A PIC

THIS MONTH, WE'LL DISCUSS THE VIRTUES OF the new Microchip PIC18F67J60 and build up an Ethernet system based on the single-chip Ethernet engine. If you read through the first couple of pages of the 472-page PIC18F97J60 family datasheet, you'll notice that the PIC18F97J60 family is composed of three variants. The PIC18F97J60 is the most feature-rich of the group hosting 100 pins with 70 of those pins capable of performing general-purpose I/O functions. The PIC18F97J60's little brother — the PIC18F87J60 — comes fitted in an 80-pin TQFP. The smallest member of the PIC18F97J60 family of single-chip Ethernet engines — the PIC18F67J60 — is contained within a 64-pin TQFP. The PIC18F87J60 offers 55 usable general-purpose I/O pins while the smaller PIC18F67J60 weighs in with 39 free I/O pins.

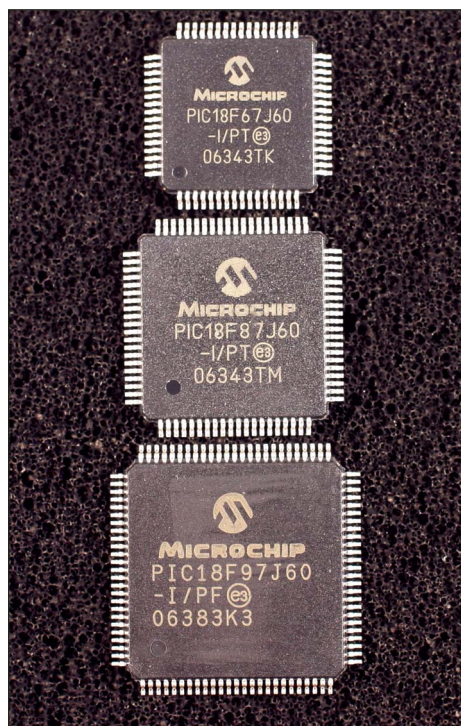
Despite their physical size and pinout, every member of the PIC18F97J60 family is equipped with 3,808 bytes of SRAM and 8KB of separate Ethernet TX/RX

buffer memory. Program Flash capacity ranges from 64KB in the PIC18F66J60, PIC18F86J60, and PIC18F96J60 to a maximum of 128KB of program Flash contained within the PIC18F67J60, PIC18F87J60, and PIC18F97J60. If 64KB is just not enough Flash and 128K is way too much program memory for your application, you can opt for the PIC18F66J65, PIC18F86J65, or PIC18F96J65, all of which house 96KB of program Flash.

For program Flash or SRAM requirements outside of the standard PIC18F97J60 family limits, you can choose to hang some external Flash or SRAM from the pins of the PIC18F96J60, PIC18F96J65, or PIC18F97J60. The only other real advantage using the high-end

PIC18F97J60 part is an extra serial port and a few more analog-to-digital converter inputs. If you don't need them, you waste them.

According to what you see in Photo 1, we can't plug any of the PIC18F97J60 family devices into a socket as every PIC18F97J60 family member is packaged in TQFP. Not to worry. Design Cycle readers eat TQFP packages for breakfast. So, in this installment of Design Cycle, we will build up an Ethernet node using the PIC18F67J60. I chose the PIC18F67J60 because it can be easily assembled from scratch with basic soldering tools. If you need the expanded, general-purpose I/O capability of the larger PIC18F97J60 or PIC18F87J60 Ethernet engines, you can still use the PIC18F67J60 support circuitry. You'll just need to lay down the larger 80-pin and 100-pin pad farms and be more careful with your soldering. Unless you have the need for a tremendous amount of general-purpose I/O, the PIC18F67J60 will do just fine in most embedded



■ **PHOTO 1.** Here's a bird's eye view of all of the current PIC18F97J60 family members. As you can see, the PIC18F67J60 is the most compact of the three. Deploying any of the PIC18FX7J60 devices would make for a very small Ethernet engine.

■ **FIGURE 1.** All of the Buffer Address registers keep up with locations of data within the PIC18F67J60's 8K Ethernet data buffer. The data that is moved between the Ethernet data buffer and the PIC18F67J60's microcontroller flows by way of the EDATA register.

Ethernet applications.

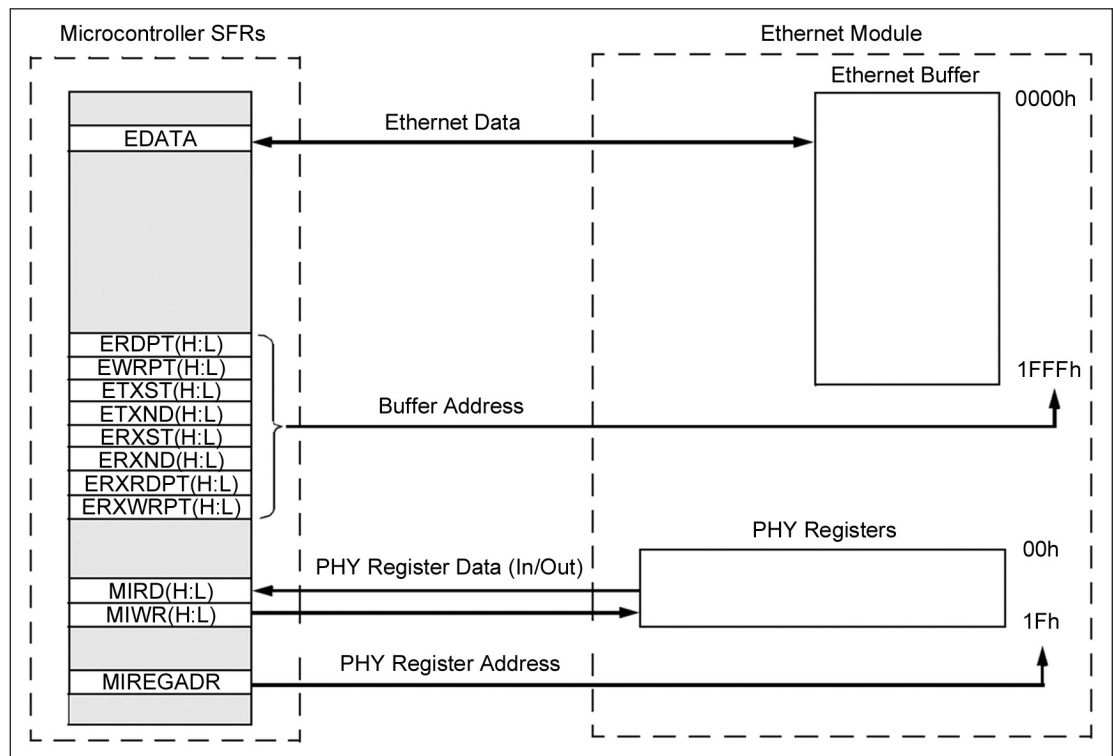
THE PIC18F67J60

Designed as a logical extension of the ENC28J60 stand-alone Ethernet engine, the PIC18F67J60 is a single-IC combination of the ENC28J60 and a PIC18 microcontroller. Everything you've come to know and love about PIC microcontrollers is part of the PIC18F67J60. Every new generation of PIC seems to be faster and the PIC18F67J60 parts are no exception, running with a maximum clock speed of 41.667 MHz with a +3.3 VDC power supply.

The PIC18F97J60 family's main reason for existence is to resolve some of the original ENC28J60's shortcomings. Depending on the speed of the SPI clock, there's only so much Ethernet data one can pump over a SPI interface in a given amount of time. The PIC18F67J60 eliminates the SPI bottleneck by incorporating the ENC28J60 on-chip with a very speedy PIC18 microcontroller. In the case of the PIC18F97J60 family members, the integrated ENC28J60 engine's memory area and SRAM buffers are directly accessible by the PIC18F67J60's PIC18 microcontroller subsystems, thus eliminating the need for an SPI interconnect between the Ethernet engine and the PIC microcontroller.

The PIC18F67J60 SFRs (Special Function Registers) are identical to the ENC28J60 registers assigned to control the flow of data to and from the PIC18F67J60's integrated Ethernet engine. So, if you've done some previous ENC28J60 work, your PIC18F67J60 learning curve will be very short. If you've studied the ENC28J60, Figure 1 is filled with familiar register pair names such as ERDPT and EWRPT. You'll also note a new register unique to the PIC18F97J60 family of devices called EDATA.

The EDATA register replaces the SPI interface on the PIC18F67J60. To feel the impact of what the EDATA register implementation does for you, take some time to walk through this function:

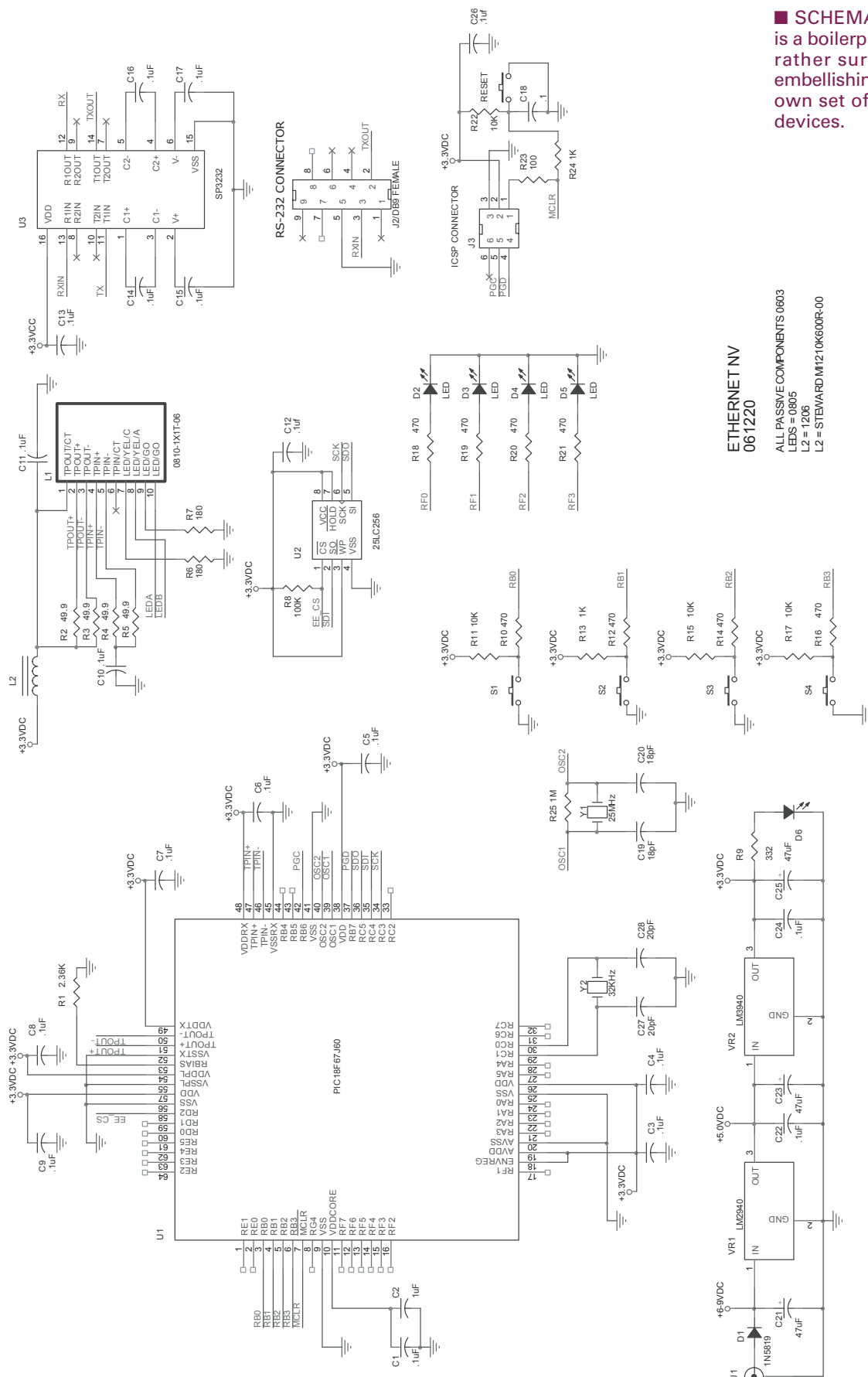


```
char rd_sram_ENC28J60 (void)
{
    enc_spi_on;           //turn SPI interface on
    SSP1BUF = RBM;        //read buffer memory command
    while(SSP1IF == 0);   //wait for command to be sent
    SSP1IF = 0;           //clear the SPI interrupt flag
    SSP1BUF = 0;          //send 0x00 for a read operation
    while(SSP1IF == 0);   //wait for read op to compete
    SSP1IF = 0;           //clear the SPI interrupt flag
    enc_spi_off;          //turn off SPI interface
    return(SSP1BUF);      //return byte of buffer data
}
```

The `rd_sram` function uses the SPI interface to read a byte from the ENC28J60 buffer SRAM that is pointed to by the ERDPTH/ERDPTL read pointer register pair. The same functionality of the ENC28J60 `rd_sram` function is invoked within the PIC18F67J60 using this simple function:

```
char rd_sram_67J60(void)
{
    return EDATA;
}
```

The ERDPT register pair (ERDPTH/ERDPTL) is used to point to the desired byte to be read from the PIC18F67J60's 8K Ethernet SRAM buffer, which happens to look just like the ENC28J60's 8K Ethernet SRAM buffer. By reading the EDATA register, the value pointed to by the ERDPT register pair is passed to the application. Writing data bytes to the PIC18F97J60's 8K of SRAM buffer area is just as easy. The EWRPT pointer pair illuminates the target SRAM to be written to and a simple write to the EDATA register puts the data into the targeted SRAM location:




```
void wr_sram_67J60(char data)
{
    EDATA = data;
}
```

If you have previously designed around the ENC28J60 stand-alone part, you know that a logic-level translation is required if you want to run some of the PIC microcontrollers as a full-speed host connected to the ENC28J60. ENC28J60 devices at revision levels below B5 have a SPI clocking restriction that requires an 8 MHz minimum SPI clock speed. To meet the 8 MHz SPI clock speed requirement, many of the PIC microcontrollers must be run at a voltage level that allows the PIC system clock to generate a SPI clock fast enough to provide reliable data flow between the ENC28J60 SPI and host PIC's SPI portal.

Many of the current PIC LF devices cannot acquire their full clock speeds at voltages less than 4.5 VDC. With the ENC28J60 being a +3.3 VDC part with non-5V-tolerant digital outputs, the ENC28J60 designer is forced into a design tradeoff, which runs the PIC microcontroller at +5 VDC and buffers the ENC28J60's digital outputs with an external buffer IC.

All of the ENC28J60's SPI design tradeoffs have been addressed in the new B5 ENC28J60 silicon. There is no longer a clocking minimum speed requirement for the ENC28J60. However, if you choose to use a PIC microcontroller that cannot attain full speed operation at +3.3 VDC, you will need to buffer the ENC28J60 digital outputs if you run the PIC host at +5 VDC. The ultimate workaround to all of the ENC28J60 design tradeoffs is to design your embedded Ethernet application around the PIC18F97J60 family of devices.

There are still plenty of applications in which the new ENC28J60 silicon can provide a best-fit solution. Everyone in the world doesn't use PIC microcontrollers in embedded Ethernet applications. However, no matter which microcontroller host you prefer, it can be attached to an ENC28J60. You'll also

need to incorporate an ENC28J60 if you are working embedded Ethernet apps with the Microchip dsPIC line of microcontrollers. So, even though the PIC18F67J60's grass looks greener, there is a reason Microchip still makes the ENC28J60 available to us.

The PIC18F67J60 is actually very easy to bring up in the hardware sense. A look at Schematic 1 shows us that the microcontroller side of the PIC18F67J60 needs nothing more than any other PIC microcontroller requires. Each of the PIC18F67J60's power pins is bypassed with a .1 μ F capacitor and a standard PIC microcontroller crystal-controlled system clock circuit is attached to the PIC18F67J60's OSC1 and OSC2 pins. The PIC18F67J60 requires a single 25 MHz crystal if the Ethernet functions of the PIC18F97J60 will be utilized. I decided to go ahead and include the 32 kHz clock circuitry, as well. I've found that having a real-time clock available to the embedded Ethernet application is always handy.

There are five PIC18F67J60 oscillator options that are common across the PIC18F97J60 family of devices. PIC18F67J60 HS (High Speed) crystal modes include the use of either a standard crystal as we have done in our PIC18F67J60 design, or a ceramic oscillator. To mix things up (and we did just that), we can enable the PIC18F67J60's PLL (Phase Locked Loop) circuitry and invoke HSPLL mode.

The PIC18F67J60's PLL subsystem consists of a 5x PLL that is sandwiched between a PLL prescaler and a PLL postscaler. Both the prescaler and postscaler can be configured to divide by two (1:2) or divide by three (1:3). The postscaler can also be configured out of the circuit (1:1).

As I mentioned earlier, we must supply a 25 MHz clock source to the PIC18F67J60 as we are intending to use the PIC18F67J60's Ethernet capabilities. Disabling the 5x PLL and the postscaler will automatically disable the prescaler and provide a 25 MHz clock frequency to the PIC18F67J60's internals. To obtain

the maximum clock frequency of 41.6667 MHz, we must enable the 5x PLL, disable the PLL postscaler, and configure the PLL prescaler for 1:3 operation.

If you do the simple math ($5 * 25 \text{ MHz} / 2$) with the prescaler set for 1:2 and the postscaler disabled, you'll see that the resultant frequency is well beyond the PIC18F67J60's operational capabilities. The minimum clock frequency that can be sustained with the 5x PLL enabled is 13.8889 MHz ($5 * (25 \text{ MHz} / 3) / 3$). Disabling the 5x PLL and maxing out the postscaler and prescaler values yields a minimum clock frequency of 2.7778 MHz. EC (External Clock) and ECPLL modes — which accept the externally generated incoming raw clock signal through the OSC1 pin — will work in the clock frequency domain exactly like the HS and HSPLL modes.

The fifth PIC18F67J60 clocking mode is INTRC, or internal oscillator mode. One of the five PIC18F67J60 clocking modes — which becomes the primary clock — is selected using the FOSC_X trio of configuration bits. All of the PIC18F67J60's configurable oscillator components (5x PLL, prescaler, and postscaler) are set up by bits we code into the PIC18F67J60's OSC_{TUNE} register.

There's nothing new in the PIC18F67J60's MCLR circuitry and the PIC18F67J60's Microchip ICSP programming/debugging interface is also no different than any other PIC's. Outside of the PIC18F67J60's Ethernet interface, there is only one other design to-do that we must take care of. The PIC18F67J60 contains an internal +2.5 VDC voltage regulator to provide power to the PIC18F67J60's microcontroller core from the PIC18F67J60's +3.3 VDC V_{DD} supply. The PIC18F67J60's internal +2.5 VDC voltage regulator is controlled by the ENVREG pin. To enable the PIC18F67J60's internal +2.5 VDC voltage regulator, we must tie the ENVREG pin to V_{DD} . Otherwise, we would have to provide a source of power for the PIC18F67J60's microcontroller core externally. Since we will be running our PIC18F67J60 at +3.3 VDC, I personally prefer tying

SOURCES

■ **Microchip** — Microchip TCP/IP Stack, PIC18F67J60, MPLAB ICD 2 — www.microchip.com

the ENVREG pin logically high and adding a pair of 1 μ F and .1 μ F filter capacitors tied to the PIC18F67J60's V_{CAP} pin over the incorporation of an external +2.5 VDC power supply circuit.

I listen to Design Cycle readers and I'm always looking at ways to cut the costs of Design Cycle projects. To keep the costs of this project down, the PIC18F67J60 and associated circuitry will be built up on a simple, double-sided printed circuit board (PCB).

When I do these types of projects, I try to put myself in the Design Cycle reader's shoes and include enough flexibility in the project to allow the readers to be able to adapt the project to their personal needs. My original idea was to include pads for both the 64-pin and 80-pin variants of the PIC18F67J60 on the same PCB. That would allow a Design Cycle reader to use either of the parts and eliminate the need to produce multiple PCBs for each PIC18F97J60 family device.

If you've ever played around with 64-pin and 80-pin TQFP pad layouts, you know that you can place the 64-pin pad layout neatly inside of the 80-pin pad layout. That works only if both the 64-pin and 80-pin TQFP pads are pitched identically. All of the PIC18F97J60 family member's pads

are pitched at 0.5 mm. The difference in the 64-pin and 80-pin TQFP packages is just four extra pins per side. If we were simply laying down a standard PIC microcontroller in the 80-pin package and did not hardwire any of the I/O, we could easily place a 64-pin pad package within the 80-pin pad package and just ignore the two general-purpose I/O pins at each flat corner when the smaller package was installed. I've seen the crafty folks at microEngineering Labs do that with some of their universal PIC development boards.

Unfortunately, in the case of the PIC18F97J60, the Ethernet differential inputs and outputs ride on two of the corners in the outermost pin positions. The PIC18F67J60's 64-pin package Ethernet differential pins shift into the general-purpose I/O pins of the PIC18F87J60 80-pin package. So, I scrapped the idea of multiplexing PIC18F97J60 family devices on a single PCB.

The PIC18F67J60 Ethernet interface circuitry is identical to that of the ENC28J60. Our PIC18F67J60 Ethernet interface design is built around the Bel Fuse BM0810-1X1T-06 10/100Base-TX belMag, which includes integral indicator LEDs. The LEDs are simply indicators as far as the PIC18F67J60 is concerned. Recall that the ENC28J60 uses the indicator LEDs to determine portions of its duplex configuration at power-up. The PIC18F67J60 multiplexes the Ethernet indicator LEDs with general-purpose I/O pins on PORTA and you can forego the Ethernet indicator functions and use the PORTA RA0 and RA1 pins for I/O purposes.

One other difference is the external bias

resistor, which for the PIC18F67J60 is specified as 2.26K. The value of the external bias resistor varies from revision level to revision level on the ENC28J60 parts. The bias resistor is essential to the operation of the PHY module's internal analog circuitry and influences the TPOUT signal amplitude. Messing around with the value of the bias resistor may cause the Ethernet transmit waveform to violate the IEEE 802.3 specification. So, to keep from getting an IEEE 802.15.4 ticket, you want to use the RBIAS resistor value that Microchip specifies.

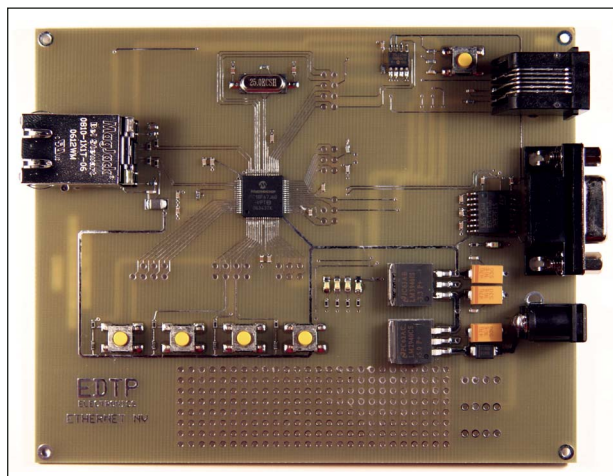
The PIC18F67J60 stands alone in the most part. However, it is not totally independent. So, let's turn our attention to the rest of the PIC18F67J60's supporting circuitry.

PIC18F67J60 SUPPORT CIRCUITRY

The driving force behind the PIC18F67J60 supporting circuitry is the firmware that will run on the PIC18F67J60. Reinventing the wheel is not something any of us want to do. Writing PIC18F67J60 driver code from scratch is like chiseling on a rock with one of the GEICO cavemen as a complete TCP/IP stack can be had for the PIC18F67J60 at no cost from the Microchip website.

To use the free Microchip stack, all we have to do is conform to the hardware conventions that are specified in the Microchip TCP/IP stack's compiler.h file. We can then pull the functions we want from the stack or implement the modules of the stack that meet the needs of our particular application. We can also fashion our own set of drivers using the Microchip TCP/IP stack's functions as prototypes.

An RS-232 serial port is a must-have. The MAX3232 can be had as an STMicro or Sipex part, which makes it easy to acquire from many sources in this magazine. Five .1 μ F capacitors plus one of the 3232 variants are all it takes to put the PIC18F67J60's serial port in place. I also included a standard six-pin RJ-12



■ **PHOTO 2.** This is a raw prototype I used while writing this installment of the Design Cycle. You can use the ExpressPCB file I've provided to produce a pretty silkscreened version, if you wish. I've included total accessibility to the PIC18F67J60's resources to allow you to pile your own stuff into the design.

jack for the ICSP portal in this design. That allows you to use the Microchip MPLAB ICD 2 right out of the box.

Many of you have written me asking about web serving and HTTP in the terms of the PIC microcontroller. You'll be glad to know that the new Microchip TCP/IP stack has enhanced its HTTP firmware. To take full advantage of the TCP/IP stack firmware, I've added a SPI-driven EEPROM in the form of a 25LC256 to the PIC18F67J60 design. The EEPROM can be used to hold web pages. If HTTP is not in your application mix, the EEPROM can be used to store anything you wish.

Every device on the PIC18F67J60 project board is powered by +3.3 VDC. However, since the PIC18F67J60's inputs are five-volt tolerant and you may need to use a +5.0 VDC-powered device, I've designed in a dual-voltage power supply to accommodate any +5.0 VDC devices you may need to incorporate into your PIC18F67J60 application.

If you decide to employ the services of the free Microchip stack, there are some portions of the Microchip TCP/IP stack that require the user to enter a function block by pressing a button attached to PORTB of the PIC18F67J60. In return, the function block may return a status via the RS-232 port or an LED. So, to make sure you can fully utilize these functions, I've added some blinky lights and pushbuttons to our PIC18F67J60 design. I recommend reviewing the Microchip TCP/IP Stack Version Log to get the lowdown on what the new version of the TCP/IP stack will do.

PIC18F67J60 LOGISTICS

To facilitate the proliferation of the PIC18F67J60 project hardware you just read about, I've supplied

an ExpressPCB layout file that you can download from the *Nuts & Volts* website. The ExpressPCB layout file will allow those of you that wish to build a PIC18F67J60 project from scratch to do so with little effort. My version of the PIC18F67J60 project we've just discussed (I call it Ethernet *Nuts & Volts* or Ethernet NV for short) can be seen in Photo 2.

In the next installment of Design

Cycle, we will walk through coding up a set of basic drivers for the PIC18F67J60. Using our little home-grown "garage stack," you will be able to do some pretty nifty things with the PIC18F67J60 without having to resort to decoding and loading any portion of the Microchip TCP/IP stack. Get ready to put another notch in your belt as you're about to add the PIC18F67J60 as part of your Design Cycle. **NV**

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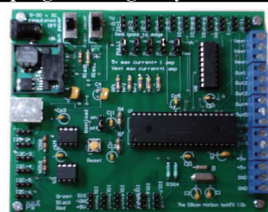
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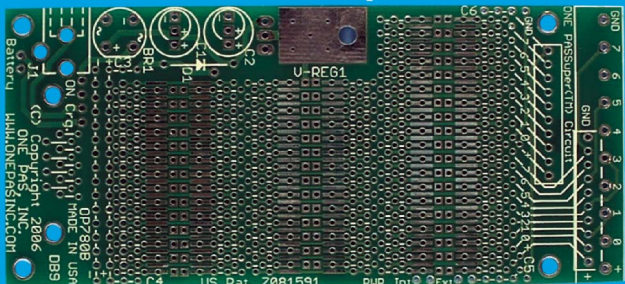
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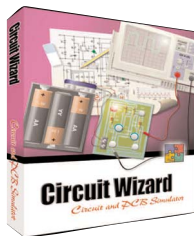
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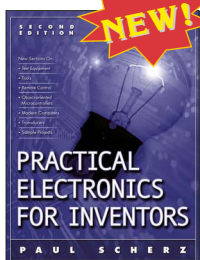
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Practical Electronics for Inventors by Paul Scherz

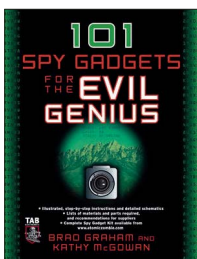
This intuitive, applications-driven guide to electronics for hobbyists, engineers, and students doesn't overload readers with technical detail. Instead, it tells you — and shows you — what basic and advanced electronics parts and components do, and how they work. Chock-full of illustrations, *Practical Electronics for Inventors* offers over 750 hand-drawn images that provide clear, detailed instructions that can help turn theoretical ideas into real-life inventions and gadgets. **\$39.95**



101 Spy Gadgets for the Evil Genius

by Brad Graham/Kathy McGowan

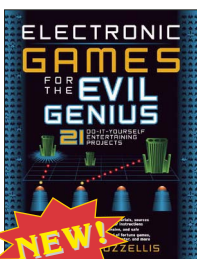
Utilizing inexpensive, easily-obtainable components, you can build the same information gathering, covert sleuthing devices used by your favorite film secret agent. Projects range from simple to sophisticated and come complete with a list of required parts and tools, numerous illustrations, and step-by-step assembly instructions. **\$24.95**



Electronic Games for the Evil Genius

by Thomas Petruzzellis

You can have a wicked amount of fun on your way to becoming a game master! In *Electronic Games for the Evil Genius*, popular how-to author Tom Petruzzellis gives you everything you need to build 35 exciting games and gadgets. You get complete, easy-to-follow plans, with clear diagrams and schematics, so you know exactly what's involved before you begin. Packed with fun projects that you'll love to build and play with, this guide develops game expertise one simple step and project at a time. **\$24.95**

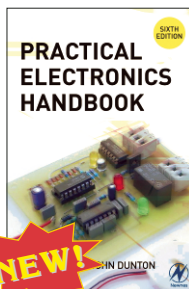


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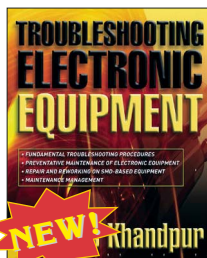
by Ian Sinclair/John Dunton

Ian Sinclair's *Practical Electronics Handbook* combines a wealth of useful day-to-day electronics information, concise explanations, and practical guidance in this essential companion to anyone involved in electronics design and construction. The compact collection of key data, fundamental principles, and circuit design basics provides an ideal reference for a wide range of students, enthusiasts, technicians, and practitioners of electronics who have progressed beyond the basics. The sixth edition is updated throughout with new material on microcontrollers and computer assistance, and a new chapter on digital signal processing. **\$39.95**



Troubleshooting Electronic Equipment by R. S. Khandpur

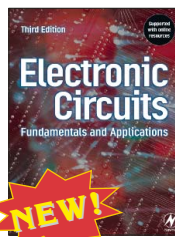
From cell phones to medical instruments to digital and micro-processor based equipment, this hands-on, heavily illustrated guide clearly explains how to troubleshoot, maintain, and repair all types of electrical equipment. The author covers all the essentials such as necessary tools, soldering techniques, testing, fundamental procedures, and mechanical and electrical components. **\$49.95**



Electronic Circuits — Fundamentals & Applications: Third Edition

by Mike Tooley

In *Electronic Circuits*, Mike Tooley provides all the essential information required to get to grips with the fundamentals of electronics, detailing the underpinning knowledge necessary to appreciate the operation of a wide range of electronic circuits, including amplifiers, logic circuits, power supplies, and oscillators. The third edition now offers an even more extensive range of topics, with extended coverage of practical areas such as circuit construction and fault finding, and new topics including circuit simulation, electronic CAD, and a brand new chapter devoted to the PIC microcontroller. **\$34.95**



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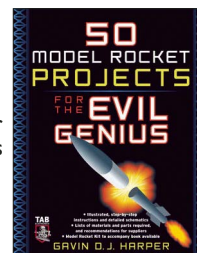
LEGO MINDSTORMS NXT Hacker's Guide by Dave Prochnow

Here is an awesome next-generation collection of LEGO MINDSTORMS projects that enables you to build and program a real working robot in just 30 minutes! New technologies and expanded sensor capabilities make it easier than ever to add a level of sophistication to robotic and architectural creations. The book explains the all-new NXT intelligent brick ... the interactive servo motors with rotation sensors that align speed for precise control ... the ultrasonic sensor that allows robots to "see" by responding to movement ... the improved light and touch sensors that let robots detect color and feel ... and much more. **\$24.95**



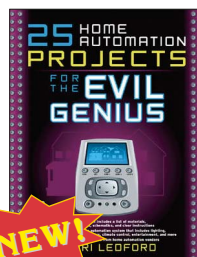
50 Model Rocket Projects for the Evil Genius by Gavin D J Harper

The fun, hands-on way to learn about rocket science. Yes, as a matter of fact, is IS rocket science! And because this book is written for the popular Evil Genius format, it means you can learn about this fascinating and growing hobby while having fun creating 50 great projects. You will find a detailed list of materials, sources for parts, schematics, and lots of clear, well-illustrated instructions. **\$24.95**



25 Home Automation Projects for the Evil Genius by Jerri Ledford

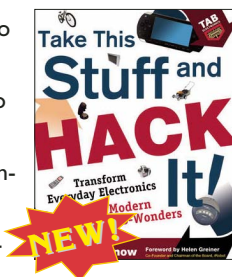
Computer technology has caught up with home automation, and it's now easy and inexpensive to automate everything in a house — including lighting, security, appliances, entertainment, and environmental conditions — and here's how to do it! This well-illustrated resource offers 25 complete home automation projects that require only basic household tools and the instructions found within its pages. **\$24.95**



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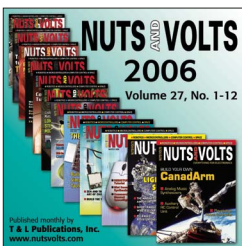
Transform common household items into really cool stuff. You don't need to be an electronics genius to get started turning everyday items into high-performing wonders. With how-to guru Dave Prochnow's step-by-step directions and fully illustrated plans, even beginners can hack their way to a high-tech home, cooler toys, and less yard work. Certain to fire your imagination and start you plotting new, original, and even more creative wonders you can make from ordinary household items, *Take This Stuff and Hack It!* is the perfect gift for your inner inventor. **\$27.95**



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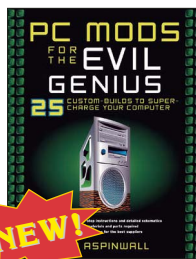
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PC Mods for the Evil Genius by Jim Aspinwall

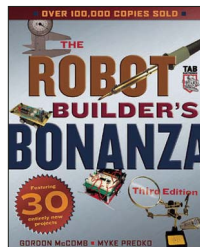
If you yearn for the coolest, most crazed 'puter around, *PC Mods for the Evil Genius* is the key to the kingdom! This book shows you how to supercharge your PC and create a jaw-dropping system that cannot be purchased off any shelf, anywhere! You get complete, easy-to-follow plans, clear diagrams and schematics, and lists of parts and tools, so you know what's needed before you begin. **\$24.95**



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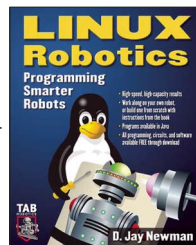
Robot Builder's Bonanza Third Edition

by Gordon McComb/Myke Predko
Everybody's favorite amateur robotics book is bolder and better than ever — and now features the field's "grand master" Myke Predko as the new author! Author duo McComb and Predko bring their expertise to this fully-illustrated robotics "bible" to enhance the already incomparable content on how to build — and have a universe of fun — with robots. Projects vary in complexity so everyone from novices to advanced hobbyists will find something of interest. Among the many editions, this book features 30 completely new projects! **\$27.95**



Linux Robotics by D. Jay Newman

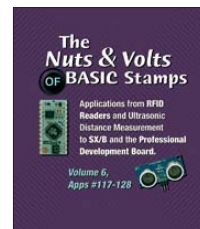
If you want your robot to have more brains than microcontrollers can deliver — if you want a truly intelligent, high-capability robot — everything you need is right here. *Linux Robotics* gives you step-by-step directions for "Zeppo," a super-smart, single-board-powered robot that can be built by any hobbyist. You also get complete instructions for incorporating Linux single boards into your own unique robotic designs. No programming experience is required. This book includes access to all the downloadable programs you need, plus complete training in doing original programming. **\$34.95**



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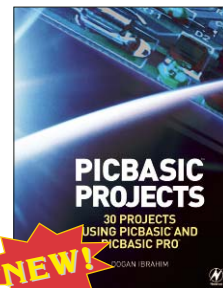
Nuts & Volts of BASIC Stamps — Volume #6 by Jon Williams

Nuts & Volts of BASIC Stamps — Volume 6 includes articles #117-128, written for 2005. Article topics consist of RFID Readers and Ultrasonic Measurement, SX/B and the Professional Development Board, the advanced MIDI receiver, programming the SX microcontroller in BASIC, mastering the MCI4489 display driver, and more! The Nuts & Volts of BASIC Stamps books are a favorite Parallax technical pick and are a tremendous technical resource for all PBASIC programming projects. **\$14.95**



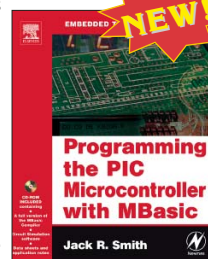
PIC Basic Projects by Dogan Ibrahim

Covering the PIC BASIC and PIC BASIC PRO compilers, *PIC Basic Projects* provides an easy-to-use toolkit for developing applications with PIC BASIC. Numerous simple projects give clear and concrete examples of how PIC BASIC can be used to develop electronics applications, while larger and more advanced projects describe program operation in detail and give useful insights into developing more involved microcontroller applications. **\$29.95**



Programming the PIC Microcontroller with MBASIC by Jack Smith

No microcontroller is of any use without software to make it perform useful functions. This comprehensive reference focuses on designing with Microchip's mid-range PIC line using MBASIC, a powerful but easy to learn programming language. It illustrates MBASIC's abilities through a series of design examples, beginning with simple PIC-based projects and proceeding through more advanced designs. **\$59.95**



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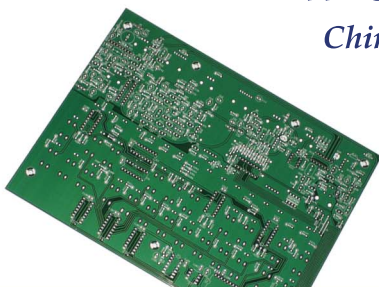
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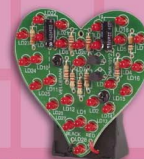


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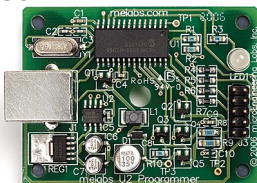
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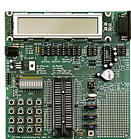
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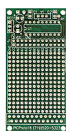
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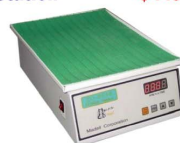


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TECH



FORUM

This is a READER-TO-READER Column.

All questions *AND* answers are submitted by *Nuts & Volts* readers and are intended to promote the exchange of ideas and provide assistance for solving problems of a technical nature. Questions are subject to editing and will be published on a space available basis if deemed suitable by the publisher. Answers are submitted by readers and **NO GUARANTEES WHATSOEVER** are made by the publisher. The implementation of any answer printed in this column may require varying degrees of technical experience and should only be attempted by qualified individuals. Always use common sense and good judgement!

All questions and answers should be sent by email to forum@nutsvolts.com All *diagrams* should be computer generated and sent with your submission as an attachment.

QUESTIONS

To be considered, all questions should relate to one or more of the following:

- ① Circuit Design
- ② Electronic Theory
- ③ Problem Solving
- ④ Other Similar Topics

■ Be brief but include all pertinent information. If no one knows what you're asking, you won't get any response (and we probably won't print it either).

■ Include your Name, Address, Phone Number, and email. Only your Name, City, and State will be published with the question, but we may need to contact you.

■ No questions will be accepted that offer equipment for sale or equipment wanted to buy.

■ Selected questions will be printed one time on a space available basis.

■ Questions are subject to editing.

ANSWERS

■ Include in the subject line of your email, the question number that appears directly below the question you are responding to.

■ Payment of \$25.00 will be sent if your answer is printed. Be sure to include your mailing address or we cannot send payment.

■ Only your Name, City, and State, will be printed, unless you say otherwise. If you want your email address included, indicate to that effect.

■ Comments regarding answers printed in this column may be printed in the Reader Feedback section if space allows.

>>> QUESTIONS

I am a member of an Old Order Mennonite Church. We do not use PCs, TVs, or the Internet, therefore, I have three somewhat unusual requests.

1. Is it possible to program microcontrollers without a PC? (A variety of sizes, say from eight DIP through 40 DIP.) Is any family of microcontrollers better suited for non-PC programming? Are there any books that would help?

2. Is there any stand-alone RS-232-C Terminals available anymore? I need one to program my late 80's Premier 2460 phone system. Could one also be used to program microcontrollers? Can someone tell me how to build one? I would prefer one that has a small QWERTY keyboard and an alpha-numerical LCD screen. The phone manual mentions a TI Silent 700 programming terminal.

3. How can I send/receive email using my fax machine?

#2071(I-3)

Leroy Sensenig
Penn Yan, NY

I'm looking for a circuit diagram that will let me know the status of a fuse in a 12 VDC circuit and 120 VAC circuit. It must light an LED to show that the fuse has blown. It would be used to monitor automotive fuses and the fuses for an amateur radio station.

#2072

Bradley Flener
Central City, KY

Is there something that can be attached to the wire that goes from my earplug to the external speaker of my police scanner that will diminish the high pitch sounds of fire calls? When an ambulance or fire station is alerted it is preceded by a series of high pitch, ear-piercing sounds which I want to eliminate.

#2073

Michael Dellaquila
via email

I'm looking to buy a YDA135 sound processor chip, but cannot find a supplier to purchase a few.

#2074

Rocky Misner
via email

I need an alternator circuit that will allow me to charge an eight-volt lead-acid battery in a WWII army vehicle using a standard automobile alternator.

#2075

Walter Bringsauf
Towaco, NJ

>>>> ANSWERS

[#9062 - September 2006]

I want to use an accelerometer as a motion sensor for a vehicle security system.

Can someone advise me on which type (capacitive, temperature, etc.) is good for this application?

Analog Devices has an application note on using one of their accelerome-

ters in car alarms. If you are interested in doing this with microcontrollers, then search **analog.com** for "ADXL202 CAR ALARMS" (no quotes) to find the application note.

Colin O'Flynn
Hamilton, ON

[#12062 - December 2006]

I have a 12V 20W-halogen light that I want to use in my car by plugging it into the cigarette lighter receptacle. The alternator produces 13.8V to 14.1V. Can I just connect the cord to a cigarette lighter plug or do I need to reduce the voltage to 12V? If I need to reduce the voltage, could someone suggest a circuit that I can fit into the cigarette lighter plug?

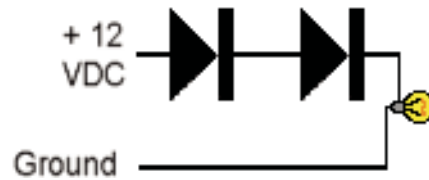
#1 The halogen lamp will work fine on 14 volts but the life is inversely proportional to the applied voltage, so if you want to extend the life, install a one-ohm, five-watt resistor in series.

Russell Kincaid
Milford, NH

#2 There is no problem plugging this directly into the cigarette lighter, especially if you are going to use the light without the engine running. However, if you intend to use the light with the engine running and are concerned about lamp life, you can drop the voltage using series-connected silicon diodes. Since you have a 20 watt light, you will need diodes that can carry at least two amps; 20 watts / 12 VDC = 1.67 amps. A readily-available part at RadioShack would be three-amp diodes; Model 1N5402; Catalog #276-1143.

The typical drop across a silicon diode is usually specified at 0.7 volts. However, at this current, you will probably find the drop to be a bit more. There will also be some voltage drop in the wiring itself. Two or three diodes in series placed between the cigarette lighter and the lamp will drop the voltage to approximately 12 VDC. Remember the diodes must be connected with the proper polarity. No damage will be done if you accidentally hook them up backwards. In that case, all that will happen is the light won't work. Just make sure they are connected in series with the lamp

and NOT directly across the battery as shown in the diagram!!!



K3PGP - John
via email

[#12064 - December 2006]

How do I interface a VGA monitor to use as a color monitor with ordinary video input?

#1 The short answer is: If you want to do it "on the cheap," you can't!

The "long" answer is: You CAN, but you need a "composite to RGBHV" video converter, and these ARE NOT CHEAP!

VGA monitors use three separate video drive lines: Red, Green, and Blue, along with the separate horizontal and video vertical sync signals. They also use different horizontal/vertical scan rates than standard NTSC video (15.75 kHz, approx. horizontal scan, 60 Hz vertical scan). Unless you plan on using a MULTISYNC monitor, you'll risk damaging the monitor and even then the best you can get is sub-VGA resolution.

If you're really set on doing it, here's an idea for a converter: DataPro Composite/S-Video to VGA Converter, \$119.00 (www.datapro.net/products/CSV-955B.html). As you can see, it's not a cheap method, but if it's worth it to you, it's something to consider.

Ken Simmons
Auburn, WA

#2 I have been using a product for the past year from KWORLD with very good success. It has a standard 15 pin VGA connector that connects to the computer monitor. Besides a built-in standard TV tuner, there are inputs for composite video and S-Video.

Manufactured by: KWORLD
Mfg Part No: VS-TV1531R
UPC No: 872880886919

This item is available through

Amazon.com for \$49.97: www.amazon.com/Kworld-TV-LCD-Resolution-1280x1024/dp/B000234W2C and Tigerdirect.com for the same price: www.tigerdirect.com/applications/SearchTools/item-details.asp?EdpNo=674680&CatId=1427

Specifications

Video Input:

TV: Coaxial (RF)
Video 1: Composite Video
Video 2: S-Video
VGA: Eight pin DB

Video Output

Output 1: VGA 15 pin DB
Output 2: Composite Video for TV Display

Audio Input

Audio 1: External Audio (RCA)
Audio 2: Line-In From PC sound card

Audio Output

Stereo Audio Output to Speaker

K3PGP - John
via email

[#12065 - December 2006]

I need a 16-pin TCA280AI to repair an auto body spot welder. It is a general-purpose trigger circuit. Are there any companies that will sell me this chip without having to pay the typical \$200 to \$500 minimum fee for a \$15 to \$20 chip?

First try the usual hobbyist sources for parts. Some of the common ones are Mouser Electronics, Jameco, All Electronics, and Global Electronics. If these fail, some of the commercial suppliers, such as Newark Electronics, will fill small orders, and the minimum order is usually about \$25, not hundreds. If all else fails, one desperation move I've used is to contact the manufacturer of the part and ask for a sample. Sometimes, to keep good public relations, the company will send one or two for free (especially if they think it's for a prototype that will eventually lead to multiple sales).

Howard Mark
Suffern, NY

[#12066 - December 2006]

As I travel the highways, I often wonder if the road is going up or down and by how much. One reason is that I might typically shut the air-

conditioning compressor off when going uphill to save energy, but turn it on when going downhill as the engine is idling and the energy to drive the air-conditioner is essentially free.

GPS units are fairly accurate at computing altitude. Are directional accelerometers or GPS units sufficiently quick and accurate to produce such a signal? I have also seen digital levels that must produce an off level signal to send to a readout or display. How might these devices be used?

#1 The two most common ways of determining elevation and changes in elevation are GPS and barometric pressure.

I'm not sure what kind of hills you are dealing with, but where I live, there is no problem determining whether the vehicle is going uphill or downhill as the hills are STEEP! So I have to assume you are concerned about topography which is not as severe as what I have to deal with.

For the past year, I've been using a Vetta V100a bicycle computer on my bicycle. It not only displays present elevation but also indicates grade and whether the elevation is increasing or decreasing. It senses barometric pressure to do this.

If you are looking for something with an audible output, look around for what is called a Variometer. However, unless you like looking at rotating inductors, I suggest you type paraglider, ultralight, aircraft, or barometric pressure along with variometer when using an Internet search engine such as Google.

If you want the ultimate change of elevation indicating

device which will read out the ELEVATION TO A THIRD OF AN INCH, you might want to check out the UP24 - High Resolution Air Pressure / Elevation Sensor Kit sold by Ramsey Electronics; www.ramseyelectronics.com/cgi-bin/commerce.exe?preadd=action&key=UP24.

K3PGP - John
via email

#2 What you are describing is more along the lines of an "inclinometer." They are often used in off-roading vehicles, so you can find a supply of them at any nearby off-roading store. As well, you can check eBay or similar for low-cost options.

If you wish to do this yourself, there are still other options. You can purchase inclinometer sensors directly. The absolute cheapest will be found at a hardware store. It is designed to be used to measure the angle of any surface, and is essentially a stiff piece of plastic with a weight on the end that is free to rotate. It will always point down, so by fixing a scale behind it relative to the surface, you know the angle. This won't work if you are accelerating or bumping around in the car though, as it will throw the readings off.

To use one of the many MEMS accelerometer devices you have seen around, check out Freescale's application note on the subject, AN3107. As well, see the article on a self-balancing robot, Part 2, which appeared in the December issue of *Nuts & Volts*. GPS could potentially work, but you would need a device that can receive WAAS signals for an accurate enough fix. Search eBay for "GPS Mouse"; there are a number of GPS units about the size of a computer mouse you can get. They are sealed and have a magnet mount so you can put them on top of your car. Get one with serial output and you can interface it to a microcontroller/Stamp device. They all output NMEA data, if you search the web, you'll find all sorts of example code for interfacing. Then it's just a matter of seeing if your altitude is going up or down.

Colin O'Flynn
Hamilton, ON

[#1074 - January 2007]

What is the frequency and mode used by the small outdoor temperature transmitters? Is the data serial? Is there a standard format?

I have found many of the weather forums say that several transmitters are on 433.970 MHz. Yes, the data is serial. There are some "standard" formats, but many do not follow them. My \$60 weather station certainly does not, according to the discussions. There is a forum I have found very useful www.weathermatrix.net/. Several of the weather stations use chips by Dallas Semiconductor/Maxim and therefore could be called a sort-of standard. Of course, if you have a simple thermometer, it might not be using the same chips as the weather stations. If you do a search for 433 weather, you will see many weather-related items pop up, but I suspect the frequency is between 433 and 434, not exactly 433.

Joe Heck
Wrentham, MA

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- Horizontal Resolution: 480TV lines
- Min. Illumination: 0Lux

Item# **VC-827D: \$132.00**

SONY Super HAD CCD™ equipped camera's feature dramatically improved light sensitivity

SONY Super HAD CCD B/W Weatherproof IR Camera

- Day & Night Auto Switch
- Signal System: EIA
- Image Sensor: 1/3" SONY Super HAD CCD
- Horizontal Resolution: 420TV lines
- Min. Illumination: 0Lux

Item# **VC-317D: \$59.50**

[Details at Web Site](#)

SONY Super HAD CCD Color Camera

- Weather Proof
- Signal System: NTSC
- Image Sensor: 1/4" SONY Super HAD CCD
- Horizontal Resolution: 420TV lines
- Min. Illumination: 1Lux/F1.2

Item# **VC-805: \$53.95**

> Miniature Cameras(Board,Bullet,Mini's, B/W, Color)

SONY Super HAD CCD Color Weatherproof IR Camera

- Day & Night Auto Switch
- Signal System: NTSC
- Image Sensor: 1/4" SONY Super HAD CCD
- Horizontal Resolution: 420TV lines
- Min. Illumination: 0Lux

Item# **VC-819D: \$62.50**

Stepper Motors

Part #:	Motor Frame Size:	Holding Torque:	Price:
42BYGH404	NEMA 17	3.4kg.cm/47oz.in	\$17.95
57BYGH207	NEMA 23	8kg.cm/111oz.in	\$24.95
57BYGH303	NEMA 23	15kg.cm/208oz.in	\$29.95
57BYGH405	NEMA 23	20kg.cm/277oz.in	\$34.95
85BYGH350B-03	NEMA 34	48kg.in/665oz.in	\$79.95
85BYGH350C-03	NEMA 34	63kg.cm/874oz.in	\$119.95

**Stepper Motor Controllers 2 Phase Microstepping Stepper Motor Driver (Bi-polar & Unipolar Motors)**

Part #:	Dimensions:	MicroStep:	Price:
XCW220	100mm x 61mm x 19mm	1(200), 1/2(400), 1/4(800), 1/8(1600)	\$39.95
CW220	99mm x 65mm x 30mm	1/2(400), 1/8(1600)	\$49.95
CW230	115mm x 72mm x 32mm	1(200), 1/2(400), 1/4(800), 1/8(1600), 1/16(3200), 1/32(6400), 1/64(12800)	\$59.95
CW250	140mm x 94mm x 45mm	1(200), 1/2(400), 1/8(1600)	\$69.95
CW860	147mm x 97mm x 30mm	1(200), 1/2(400), 1/4(800), 1/8(1600), 1/16(3200), 1/32(6400), 1/64(12800), 1/128(25600), 1/50(10000), 1/125(25000), 1/250(50000)	\$119.95

**Protek****Protek 2.0 & 2.9GHz Field Strength Analyzers**

- Frequency Range : 100KHz ~ 2900MHz (2060MHz for 3201N)
- WFM/NFM/AM/SSB modulated signals may be measured.
- Sweep Trigger Mode: Free Run, Single Run, Continuous Wave, Squelch Run
- Sweep Speed: 500 to 2000msec
- PLL tuning system for precise frequency measurement and tuning
- Built-in Frequency Counter
- RS232 interface



Item#'s **3290N & 3201N**

[Details at Web Site](#)

> Test Equipment > RF Test Equipment

Special

\$1899.00 (for 3290N)
\$1374.00 (for 3201N)

Outdoor Color Speed Dome Camera

- 1/4" SONY Exview CCD
- 768(H) x 494(V) effective pixels
- Horizontal Resolution: 480TV lines
- Up to 80 preset points
- Line scanning
- Continuous 360° horizontal rotation
- Vertical rotation: 0-100°
- RS485 control interface
- Min. Illumination: 0.1Lux (color) / 0.001Lux (B&W)

Item# **VC-EX861**
\$899.00



[Details at Web Site](#)

> Miniature Cameras(Board,Bullet,Mini's, B/W, Color)

Shown with optional wall mount!



480 TV Lines Resolution



Visit our website for a complete listing of our offers. We have over 8,000 electronic items on line @ www.CircuitSpecialists.com. PC based data acquisition, industrial computers, loads of test equipment, optics, I.C's, transistors, diodes, resistors, potentiometers, motion control products, capacitors, miniature observation cameras, panel meters, chemicals for electronics, do it yourself printed circuit supplies for PCB fabrication, educational D.I.Y. kits, cooling fans, heat shrink, cable ties & other wire handling items, hand tools for electronics, breadboards, trainers, programmers & much much more! **Some Deals you won't believe!**

START MAKING SENSE



Ready to work with sensors, but unsure of where to begin?

Expand the horizons of your BASIC Stamp® projects with tilt and acceleration sensing, compass readings, and ultrasound distance detection. Then, display your data using the advanced techniques included for the Parallax 2x16 Serial LCD. The *Smart Sensors and Applications* text provides a well-illustrated in-depth introduction to each device included with the kit:

- Measure distance with the PING)))™ Ultrasonic Distance Sensor, accounting for the change in the speed of sound with air temperature.
- Make a tilt-controlled video game and an acceleration datalogger with the Memsic Dual-Axis Accelerometer.
- Get oriented with the Hitachi HM55B Compass Module.
- Display sensor readings as scrolling text, bar graphs, custom characters and animations with the Parallax 2x16 Serial LCD.
- All electronic components for the bread board circuits, LCD extension cables, and LCD mounting brackets are included.

This advanced Stamps in Class text is a perfect sequel to *What's a Microcontroller?* or *Robotics with the Boe-Bot*. All the activities in *Smart Sensors and Applications* require a BASIC Stamp 2 module and a Board of Education® (Board of Education Full Kit; #28103), or a HomeWork Board (available with the BASIC Stamp Activity Kit; #90005).

System requirements: A PC running Microsoft Windows® 2000/XP, a serial or USB port for your board, and the free BASIC Stamp Editor software.

Order the *Smart Sensors and Applications* parts and text kit (#28029; \$129.95) online at parallax.com or call the Parallax Sales Department toll-free at 888-512-1024 (Mon-Fri, 7am-5pm, PT).

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